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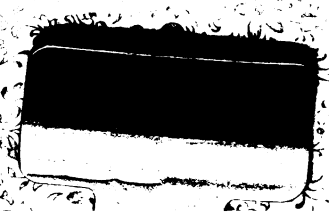

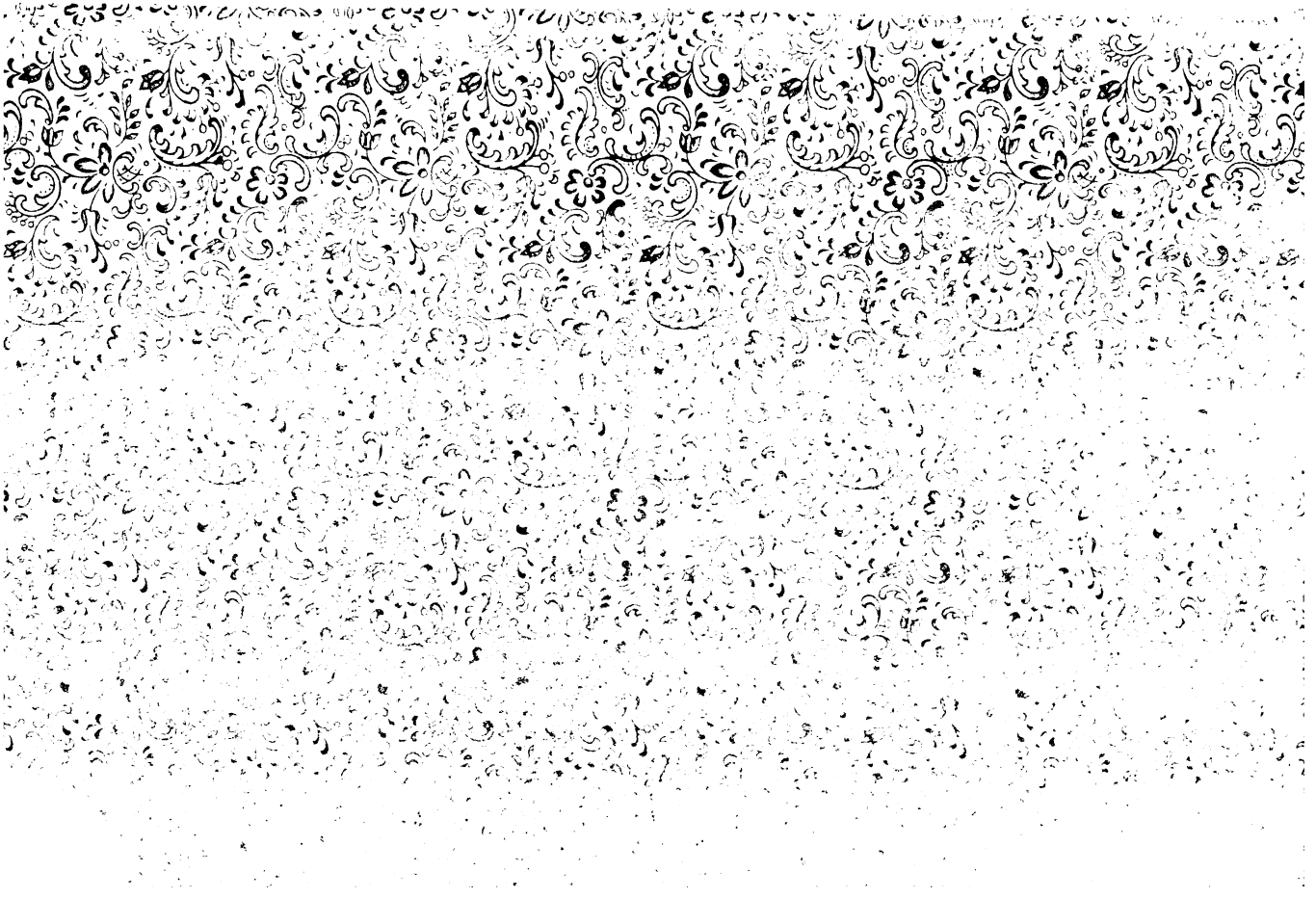

FRICTION AND LUBRICATION.

A PRACTICAL TREATISE

ON

FRICTION, LUBRICATION, FATS AND OILS,

INCLUDING

THE MANUFACTURE OF LUBRICATING OILS, LEATHER OILS, PAINT OILS, SOLID LUBRICANTS AND GREASES, TOGETHER WITH NUMEROUS FORMULAS; MODES OF TESTING OILS, AND THE APPLICATION OF LUBRICANTS.

BY

EMIL F. DIETERICHS,

MEMBER OF THE FRANKLIN INSTITUTE, PHILADELPHIA, MEMBER OF THE NATIONAL ASSOCIATION OF STATIONARY ENGINEERS, AND INVENTOR OF THE DIETERICHS "VALVE-OLEUM" LUBRICATING OILS.

SECOND EDITION, THOROUGHLY REVISED AND ENLARGED.

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PREFACE TO THE SECOND EDITION.

THE exhaustion within a comparatively short time of the first edition of "A Practical Treatise on Friction, Lubrication, Fats and Oils" and the constant demand for it, are the best evidence that it has given satisfaction, and no apology is therefore necessary for presenting the second edition.

While but few alterations have been made in the text of the book and no essential portions have been omitted, it has been thoroughly re-revised and considerable new matter, particularly a number of useful formulas for lubricants from abroad, has been introduced, as well as a review of the efforts and progress made during the last decade in the petroleum industry.

I wish to state that I cordially agree with the timely criticism the editor of "The Petroleum News", published in Cleveland, Ohio, has made about the lamentable lack of proper facilities in the laboratories of colleges and schools of science for more practical instruction for young students of chemistry to make researches on a scientific basis of the petroleum industry so valuable to the prosperity of the country. Congressional action is

too slow and too indifferent, but moneyed philanthropists could ingratiate and distinguish themselves by the foundation and endowment of a practical laboratory conducted by able chemists in conjunction with intelligent practical oil men, where investigations of progressive conceptions could be tested and developed on a practical scale.

Many rich men have obtained their wealth not by improvements conceived by them, but by speculations on the commercial value of the petroleum industry.

E. F. DIETERICHS.

CLEVELAND, OHIO.
December, 1915.

PREFACE TO THE FIRST EDITION.

FROM observation during a period of nearly fifty years as a practical Chemist and Manufacturer of Chemical Products and all kinds of Oils, and my close connection with Engineers and Manufacturers, and experience with the endless varieties of Engines and Machinery in use, I have long felt the need of some work that would collectively treat in a condensed and comprehensive form the subjects of Friction, Lubrication, the origin and characteristics of Fats and Oils, their Uses, their Adulterations and their Practical Testing, all of such vital importance in the mechanical world.

In the effort to produce a book to fill these wants and make it useful as well as easily understood by Mechanics and Manufacturers not very familiar with these subjects, I have throughout avoided as much as possible all scientific technology, as well as technical terms and theories familiar only to the experienced chemist, and have endeavored to write in such language and manner as can be readily comprehended by anybody with an ordinary school education.

I would here take occasion to acknowledge the endorsement given to my former writings and to my lectures on these subjects, and to the generous patronage extended to my "valve-oleum" lubricating oils.

My theories on lubrication, which led to the production of the "valve-oleum" oils, at first met with much derision. But notwithstanding the fact that I have made many efforts to arouse, by my publications and lectures, more attention to, and to elicit information upon, the subject, thus far no sound argument has been advanced to refute these theories or to uphold those other ones, older and long persistently held.

Should I have been successful in producing such a treatise as will meet the demands of the time—and with this faith, I hereby dedicate this volume to manufacturers, and mechanics, and to my brother engineers of the National Association of Stationery Engineers of America—I shall feel myself amply repaid for my labor.

As is the practice of the publishers, the book has been supplied with a full table of contents and a thorough index, rendering reference to any subject in it prompt and accurate.

E. F. DIETERICHS.

CLEVELAND, OHIO,
September 15, 1906.

CONTENTS.

I.

FRICTION.

PAGE

Definition of friction; Various kinds of friction; Explanation of the law of friction 1

Co-efficient of friction, and rule for finding it; Friction of quiescence; Friction of motion; Rolling friction . . 2

Friction of a cart on a macadamized road; Friction on a railway; Value and usefulness of friction; Frictional heat 3

II.

LUBRICATION.

Necessity of lubricating; What is lubricating; Laws of lubrication as taught by nature 4

Lubrication of the joints of the bones in the body by the joint water 5

Absorption of frictional heat by metal; Effect of overheating the bearings; Creation of frictional heat as shown by Count Rumford's experiments 6

Accumulation and disposal of frictional heat; Capacity of inert matter for absorbing and carrying away frictional heat 7

Necessity of renewing the lubricant 8

Lubrication a chemical process; The chemical process which takes place when oil is used for lubricating . . 9

Why oil and fatty matter are used for lubricating; Absorption of frictional heat by water and ice 10

Use of molasses for lubricating machinery; Conclusion . 11

PAGE

III.

Oils and Fats.

Definition of oils; Classes of oils; Fixed oils; Volatile or essential oils 12
Drying oils; Non-drying or fatty oils; Fatty oils in general use for lubricating and in the manufacture of lubricants. 13
Mineral oils and petroleum oils, and their constitution . 14
Manner of obtaining mineral oils; Nature of petroleum oils. 15

IV.

Oils and Fats of Mineral and Vegetable Origins, their Preparation, and How they are Obtained.

Lard and lard oil; Preparation and properties of lard; Separation of olein from lard 16
Lard oil and its properties; Commercial grades of lard oil; Tallow and tallow oil; Mode of obtaining tallow . . 17
Tallow oil and its properties; Neatsfoot oil and horse tallow oil; Neatsfoot oil and its properties 18
Bone fat, bone grease, and marrow tallow; Horse tallow and its properties; Elain or red oil and its properties . 19
Spermaceti and fish oils; Spermaceti, its constitution and properties 20
Sperm oil and its properties 21
Seal oil; Whale and train oils; Commercial fish oils . 22
Wool fat, degras; Modes of obtaining wool fat . . . 23
Mode of obtaining degras; Factitious degras; Castor oil and its properties 24
Olive oil and its properties 25
Sunflower oil 26
Sesame or gingelly oil; Cottonseed oil and its properties. . 27
Rapeseed or colza oil; Hempseed oil 28
Palm oil and cocoanut oil; Copra; Palm oil or palm butter; Almond oil 29
Poppyseed oil; Corn oil 30
Peanut oil and its properties 31

PAGE
Mustardseed oil; Nigerseed oil; Linseed oil . . . 32
Linolein; Driers; Uses of linseed oil 33
Receipts for the manufacture of German soft soap; Green German soap; Preparation of liquor of potassa; Green soap from hempseed oil 34
Transparent linseed oil soap 35
Transparent soft soap in the semi-cold way . . . 36
Soft linseed oil soap with a yield of 450 per cent. . . 37
Rosin, rosin oil and turpentine; Mode of obtaining rosin, and its properties 38
Distillation of rosin oil; Oil of turpentine; Rosin or pine oil, and its properties; Glycerin, and its properties . 39

V.

Clarifying, Refining and Bleaching Oils and Fats.

Various processes of bleaching vegetable oils; Clarifying oils. 41
Refining oils by treatment with sulphuric acid; Refining oils and fats with caustic soda 42
Bleaching with chlorine; Deodorizing oil 43
Bleaching and deodorizing degras 44
Cleaning and bleaching tallow and other fat; Cleaning and bleaching and deodorizing train oil 45
Bleaching grease; Action of fats and oils on metals . . 46

VI.

Mineral Oils.

Mode of obtaining mineral oils; Distillation of mineral oil. 48
Green oil, and its treatment; Paraffine oil; Treatment of shale oil; Grades of illuminating oils 49
Tar oils; Distillation of wood and products obtained thereby 50
Products obtained by the distillation of tar from gas works; Difference between benzol and benzine; Conversion of nitro-benzol into aniline oil; Uses of coal tar . . . 51

PAGE

VI.

PETROLEUM OILS.

Deposits of petroleum; Petroleum oils of Pennsylvania . 52
Ohio crude oils and manner of desulphurizing them; Use of aluminium chloride as a desulphurizing agent . . 53
Distillation of petroleum 54
Classification of the proceeds of distillation . . . 55
Neutral distillates and their division 56
Purifying and bleaching the neutral oils; Extraction of paraffine wax from crude paraffine oils. 57
Uses of paraffine wax; Golden machine oil; Steam refined cylinder oil; Production of a good cylinder oil from crude oil 58
Black lubricating or West Virginia oil; Filtered cylinder stock; Vaseline, cosmoline, petrolatum; Petroleum oils for various lubricating purposes 59
Uses of petroleum 60
Deblooming petroleum oils 61
Deodorizing petrol oil 62

VIII.

MANUFACTURE OF LUBRICATING OILS.

Lubricants for heavy pressure and low-speed machinery. . 63
Compounding petroleum oils to give them a viscous consistency; Compounding cylinder oil; Use of degras in compounding cylinder oil 64
Compounding engine and machinery oil; Various fats and oils used in the compounding of cylinder and other oils. 65
Use of rosin oils in compounding lubricating oils . . 66
Receipts of lubricants used in Germany; Cohesion oils . . 67
Lubricants for threshing machines; Automobile oil; Mineral oil lubricants 68
Sewing machine oil; Lubricants for ice machines; Lubricating oils with rosin oils 69
Thickened oils 70

PAGE

IX.

"VALVE-OLEUM" OILS.

Materials which form the foundation of "Valve-Oleum" oils 71
Preparation of oleate of alumina 72
Table of proportions of caustic soda to grease or oils for oleate of soda in the manufacture of the Valve-Oleum lubricating oils 73
Preparation of a heavy and stringy mineral castor . . 75
Preparation of "Valve-Oleum" engine and cylinder oils . 76
Preparation of white "Valve-Oleum" castor oil, "Valve-Oleum" castoroleum, or commercial castor oil, and "Valve-Oleum" linoleum 77
Origin of "Valve-Oleum" oils 78

X.

LEATHER OILS.

Necessity of lubricating leather belts, harness, boot and shoe leather 80
Oil for tanners' use; Cheap harness oil; Black harness oil; Good belt oil 81
Belt grease; Fluid adhesion fat 82
Factitious paint oil; Cheap paint oil 83

XI.

ADULTERATIONS OF FATTY OILS.

Materials used in the adulteration of lard oil, olive oil, sperm oil, linseed oil 84
Adulteration of castor oil 85

XII.

TESTING OILS.

Alkali tests for detecting the presence of hydrocarbon oil in fatty oils 86

PAGE

To ascertain the amount of mineral oil in fatty oils; Color test 87

Test for cottonseed oil in lard oil; Preliminary test for neutral oil in lard oil; Detection of small quantities of fatty oils in mineral oil; Detection of soap dissolved in mineral oil 88

Detection of acidity or alkali in mineral oil; Simple and practical methods for testing oils and oil mixtures . . 89

Detection of the admixture of petroleum in large proportions to a fatty oil; Mode of ascertaining with what proportion of petroleum a fatty oil has been adulterated . 91

Mode of telling the presence of petroleum in fatty oils, even in very small proportions; Means employed to prevent the detection of adulterations of fatty oils by the hydrometer test 92

Testing the comparative efficiency of oils for lubricating; Viscosity, and mode of ascertaining it 93

Cold test; Fire test 94

Test frequently used for cylinder oil; Simple way of testing lubricating oils 95

Practical tests of lubricating oils 96

Necessity of cleaning cylinders and bearings before testing and using a new oil 97

Advantage of the stringy character of "Valve-Oleum" oils; Detection of oleate of alumina in mineral oil . . . 98

XIII.

Solid Lubricants. Greases.

Constitution of solid lubricants and their application; Constitution of grease 100

Character of machinery for which solid lubricating grease is used; Wear and abrasion of the metal with grease lubricants; Addition of inert matter to grease . . . 101

Manufacture of greases; Preparation of lime paste for rosin grease 102

PAGE

Preparation of rosin grease in the cold way; Formulas after which nearly all grease lubricants are manufactured . 103
Preparation of cup grease, dark axle grease, linseed oil grease . ; 104
Palm oil grease; Yellow axle grease; Axle grease prepared in the cold way 106

XIV.

Some Practical Suggestions.

Cause of injuries to a cylinder; Lubrication not effected by inert matters 108
Decomposition of all fatty oils and fats by the absorption of steam and frictional heat; Injurious action from the use of tallow in cylinders 109
Small marble-like balls formed by the motion of the piston; Consequences of the softening and dissolving of hardened deposits; Other causes of injury in cylinders . . . 110
Injury to cylinders by poor packing; Causes of cutting and scarring the metal; Cutting of metal by acid in oil . . 111
Necessity of keeping clean and carefully examining the parts of machinery where oil is used for lubricating . 112

XV.

Lubricators and Cups.

Troubles to engineers caused by lubricators; Pumps for applying cylinder oil 113
Automatic pumps; The Moses pump; Feeding cylinder oil through the sight-feed cup; Principle on which sight-feed cups are devised; Cleaning sight-feed cups . . 114
Consequence of cleaning the cup by blowing live steam through it 115
Regulating the flow of oil in the cups; Cups which feed with a wick; Cups separated with a metallic stem . . 116
Cups for feeding grease 117
Only reliable lubricating with grease 118

PAGE

XVI.

Specific Gravity.

Definition of specific gravity; Standard for solid and liquid bodies; Mode of ascertaining the specific gravity by the Baumé hydrometer 120
Table of Baumé degrees, the specific gravity they represent, and the corresponding weight of the liquids per gallon 121

XVII.

Review of the Petroleum Oil Industry to 1915.

The best information on the petroleum oil industry published thus far; Early impressions as to where petroleum oil could be found 124
Transformation of prehistoric vegetation and animal life; Separation of the component parts of petroleum by distillation. 125
Products for commercial purposes obtained by distillation; Application of petroleum oils and gasoline as motive power 126
Formation of new crude oil compounds by destructive distillation of distillates of petroleum oils; The cracking process 127
How the full amount of gasoline can be procured from a given amount of petroleum oil; Little improvement in the production of lubricating oils during the last decade. 128
Introduction of the "Valve-Oleum Oils; Improvement in the production of paraffine; Lack of encouragement to inventors 129
Fallacy of the claim to be able to change the characteristics of petroleum oils so as to produce from them aniline oils. 130

Index 131

I.

FRICTION.

THE force which is felt to resist the motion when one body rubs against another while in motion is called friction. Of all mechanical power used, a large amount is spent or lost to overcome the obstructive force of friction, and means are looked for to reduce this as much as possible. Friction is either sliding or rolling. The laws regarding friction are explained as follows:

When placing a block of wood or iron on a smooth surface of wood or metal, it requires a force of some two-fifths of the weight of the block to make it move along the surface, thereby indicating the friction between the surface, as has been established by carefully conducted experiments. It has been established that two such blocks placed on the plate side by side, so as to form one of double size, require double the force to move them, and when the blocks are placed on top of each other, there is no difference in the amount of force necessary to move them. The friction between any two surfaces increases in

proportion to the force with which they are pressed together, regardless of the extent of the surface in contact. A difference, however, exists when wood on iron, iron on iron or, iron on brass press on each other. For oakwood on iron, the moving force required is about two-fifths, or exactly thirty-eight per cent; for iron on iron forty-four per cent, and for cast-iron upon brass about twenty-two per cent, in a dry state and without lubrication. The proportion expressed between the pressure of two surfaces and their friction is called their co-efficient, and is found by dividing the power by the weight moved. The friction of quiescence, or the resistance to the commencement of motion, is greater than the resistance to its continuance, and more so if the surfaces have for a considerable time rested in contact with each other. The friction of motion is entirely independent of the velocity of the motion. The resistance of friction to a shaft turning in its bearings, or of an axle in its box, has evidently a greater leverage the thicker the journal or the axle is, and axles of wheels are accordingly made as small as is consistent with their required strength. The resistance that takes place between the circumference of the wheel on the road is called "rolling friction." In front of the wheel there is always an eminence or obstacle which it is at every instant surmounting and

crushing; so also on iron rails, but to a much lesser extent than on other roads. On the principle of the lever, it shows that a larger wheel has the advantage over a smaller one, and it has been fully established that on a horizontal road the traction varies directly as to the load, and inversely as to the radius of the wheel. On a perfectly good and level macadamized road, the traction of a cart is found to be one-thirtieth of the load, so that a horse to draw a ton must pull with a force equal to seventy-five pounds. On a railway the traction is reduced to one two-hundred-and-eightieth of the load, or to eight pounds per ton. Friction is akin to and as important as is gravitation in every motion in the universe.

While friction on railways is diminished, further dimunition would stop motion entirely, as the driving wheels of the locomotive would slide around on the rails without advancing.

Friction is most valuable when machinery with great momentum has to be checked or suddenly arrested in its motion, as by a brake against the wheels on railways. It is useful in communicating motion by means of belts, ropes or chains; it is the force that holds the knot in the rope, and it is the power that stops the momentum of cars in rapid motion. Friction is the constant opponent of motion, which creates heat, which is known as "Frictional Heat."

II.

LUBRICATION

To overcome friction and put its resisting power to as low a point as possible, we use lubricants that can absorb the frictional heat and, becoming vaporized by it, will carry the heat into space.

Lubricating is a necessity, and is the most important factor in the mechanical world. Without lubrication all the power we can obtain from Steam, Electricity, Gas, Water, Air and Horse Power, Spring and Wind Power could be of no use to us, and travel on railroads and steamboats, the running of factories, the riding in automobiles, in carriages and wagons, the use of sewing machines, the riding on bicycles, the keeping record of time by our watches; in short, the using of anything that is dependent on mechanical motion would be utterly impossible.

We have then to investigate, "What is Lubricating?"

Nature teaches us the laws of lubrication by its wonderful workings in the human body and in the bodies of all animals. All the joints of

the bones in the body would be useless and stiff were it not for their being constantly lubricated by the so-called "Joint Water," an unctuous fluid which surrounds all the joints of the skeleton part of the body. This "Joint Water" is constantly produced and supplied by nature, and is constantly consumed by the frictional heat created by our exertions and movements, and is likewise constantly disposed of and frees the body from the otherwise accumulating frictional heat by transferring it, with the perspiration and exhalations from the body, into space. When the recuperating powers of the body fail to operate properly, from one cause or another, the inflammatory condition of the joints gives evidence of the absence of proper lubrication, and the final failing and drying-up of this lubricating "Joint Water" under diminished generating power in advanced age cause the joints to move with difficulty and pain, and in the end make them lose their usefulness altogether.

So it is with machinery.

Whenever the surface of one part of machinery in motion is bearing on the surface of another, friction is created and friction creates heat. This heat is involved and increases with the velocity and continued motion, and if not taken up and carried away by lubrication, will finally increase and accumulate to such an extent that

the machinery will have to be stopped to allow the metal to cool off.

Metal is able to absorb a large amount of frictional heat, but it is unable to free itself of it as fast as it is generated by continued and rapid motion, and the heat finally accumulates to such an extent as to overheat the bearings, and if further continued will so increase and expand the metal as to cause the parts to weld themselves tightly together. This has frequently been the case with the old style flour-mill spindles, which, after becoming overheated, were found to be so tightly welded in their steps, that they had to be chiseled out. To avoid this we have to keep the revolving parts well lubricated in their bearings, and we have to continue doing this as long as the machinery is kept in motion, and in exact proportion to the frictional heat evolved and the amount of work we expect to have done.

That frictional heat is created by motion and that it vaporizes the lubricant, is shown by the following convincing experiments made many years ago by the celebrated scientist, Count Rumford:

He had a metal vessel constructed, with hollow bottom, had a perpendicular shaft fitted to it, and had it rapidly moved by mechanical power.

He then filled the vessel with water, and in the

course of four hours ascertained that the water, by the absorption of the frictional heat generated, had attained a temperature of 140° F., and in eight hours had reached the boiling-point. After this he found the water to evaporate and gradually diminish in bulk as long as he kept the shaft in rapid motion.

If we now substitute oil for the water, we will find the oil also gradually attain the temperature of its evaporating point, commonly known as "flash or fire test," and will find it also to vaporize and gradually reduce its bulk until the shaft be stopped moving.

This shows conclusively that frictional heat accumulates, and that it is disposed of by evaporating into space; this evaporation, though continuous, is invisible. Lubricating, therefore, cannot be simply an interposition of some substance, as a sort of cushion, between the metallic surfaces of machinery in motion. Soft metallic compounds, such as plumbago and some of the finer grades and inert matter, asbestos, mica, sulphur, lime and soapstone, have been recommended and have been tried for that purpose; but it has been found that while all such substances serve well, in small quantities, to fill the interstices which exist in all metallic surfaces of bearings however highly polished, and thereby presenting a smoother bedding for the revolving

shaft, they can only absorb so small a portion of the heat created by the friction as the metal itself of which the machinery is constructed.

The capacity of plumbago and other inert matter for absorbing aud carrying away the frictional heat is very low, as they cannot vaporize, while the capacity of oil and fatty matter is very great, and we are, therefore, compelled to use oil and fatty matter for lubricating.

If lubricating would be simply a mechanical action, and if a cushion of soft metal or other inert matter, or of oil or fat, would be sufficient to prevent the gradual increase and accumulation of frictional heat, then a very limited amount of oil, fat or other inert matter, once applied, should be sufficient. We find, however, that we are obliged to renew the lubricant with regularity and in exact proportion to the frictional heat created by the motion, and in exact proportion to the amount of work we expect to do with the machinery and we have to do this as long as the latter is kept in motion.

We have then to ask: What has become of the large quantities of oil which we were compelled to constantly apply to the bearings of the machinery?

As coal and water are constantly consumed to keep the supply of steam up to move the machinery; so is oil constantly consumed to draw

the frictional heat away from the bearings. We can see how the coal and water are consumed, but we are unable to see how the oil is consumed. We can, however, find silent proof that it is so, and that lubricating is a strictly chemical process and not a mechanical one.

We know that metal cannot absorb oil, and if we allow most liberally for all possible wasting and for transformation of much of it into gummy accumulations around the bearings and in cylinders, we must admit that a very limited number of gallons from every barrel of oil used could thus be accounted for, and it remains to be seen what has become of the balance.

We well know at what temperature water is evaporated and converted into steam, and after serving its purpose to move the machinery is lost into space. Precisely the same chemical process, the transformation from a fluid into a gaseous state, takes place when oil is used for lubricating.

When the oil becomes heated by the frictional heat until its evaporating temperature is reached, it becomes, like steam, a gas, and is lost into space with the frictional heat it has absorbed in exactly the same manner as oil when distilled from a still is transformed from its fluid state into a gaseous one to be rendered to a liquid state by passing through a condenser.

This transformation takes place on every bear-

ing, although on so small a scale as to be almost entirely imperceptible to our senses. Where the revolving shaft rests heaviest in the hollow of the bearing, there is the line to be drawn where this invisible transformation of the oil from the liquid into the gaseous state takes place. This line is exceedingly small—perhaps no more than the thickness of the finest sheet of paper—but on this small line the frictional heat starts to be generated, and being taken up by a few atoms of the oil at a time, is carried with their vapors into space. When from neglect or insufficient lubrication bearings become overheated, and under the rapidly increasing temperature the few particles of oil vaporize too fast and become decomposed under the increased heat, the arising vapors, with a penetrating burning smell, prove to us the slow and mysterious process by which the oil disappears.

Lubricating is, therefore, a chemical process, and requires the interposing of such substances between the moving parts of machinery as are capable to absorb the frictional heat, and vaporized by it, carry it into space. Such qualifications are best possessed by oil and fatty matter, and we, therefore, use them for lubricating our machinery.

A continuous stream of water or the application of ice will likewise absorb and vaporize with the frictional heat, but not possessing sufficient

adhesive body, cannot prevent gradual abrasion of the metal.

It has lately been claimed that molasses could be used, like oil, to lubricate machinery, but while molasses possesses adhesive quality (viscosity) its lubricating power consists in the water contained in its body which is not efficient enough to prevent abrasion of the metal.

Conclusion.

For over forty years I have contended in my writings and lectures that lubrication of machinery is not a mechanical process, a mere interposition of some substance as a cushion between the surfaces, but is a strictly chemical process, the transformation of a substance by heat from a liquid into gaseous state. I have theretofore elaborately explained my observations on the subject of the theory of lubrication and have asked for refutation or endorsement of my contention by scientists and those acquainted with the oil industry, but I have met in publications and printed compilations only with endless chatterings about viscosity in connection with the old cushion theories, but not a word about of "what is lubrication," while it is so distinctly explained by the immense amounts of fats and oils constantly consumed and lost in the process and the constant necessity for replacement with new supplies.

III.

OILS AND FATS.

THE next question arises: What are oils and what is fatty matter? What are the characteristics, and from what sources of nature do they come, and how are they obtained?

Oils are liquid and semi-solid substances, derived from the animal and the vegetable kingdoms. They are unctuous to the touch, are insoluble in water, and possess the power of supporting combustion with flame. They are obtained from the roots, seeds, fruits and flowers of plants and trees, and from the fat of animals, by extraction, by pressure, by rendering, by boiling with water, or by distillation. They are also obtained from the mineral kingdom, from shale, and out of receptacles in the bowels of the earth.

Oils are divided into two classes: They are either oxyhydro-carbons, that is, compounds of oxygen, hydrogen and carbon, and are known as "fixed oils," or they are hydro-carbons, composed of hydrogen and carbon only, and are known as volatile or essential oils. The "fixed oils" do

not sensibly evaporate at ordinary temperature. They stain paper permanently and render it translucent. They do not distil or evaporate at the temperature of boiling water, and they have only a faint odor, like that of the substance from which they have been extracted. The volatile or essential oils evaporate freely. They have a caustic, acrid taste and an aromatic odor, and when distilled with water they pass over at 212° F.

All of the "fixed oils" have an attraction more or less powerful for oxygen. Exposed to the atmosphere, some of them become hard and resinous, and they are called "drying oils;" others thicken only slightly and become sour and rancid, and they are known as non-drying or "fatty oils." The fatty oils in general use for lubricating and in the manufacture of Lubricating Oils are:

Vegetable Oils: Olive Oil, Rapeseed Oil or Colza Oil, Cocoanut Oil, Palm Oil and Almond Oil, and many others seldom used for lubricating.

Animal Oils: Lard Oil, Tallow Oil, Neatsfoot Oil, Wool Fat, Sperm Oil and the many varieties of Fish Oils.

For lubricating purposes these oils, vegetable as well as animal, are largely compounded with mineral oils of all grades and colors and in endless proportions.

Drying Oils, more or less, are: Linseed Oil, Nut Oil, Poppy Oil, Hempseed Oil, Castor Oil, Cottonseed Oil and Rosin Oil. Some of them are used in the manufacture of greases for lubricating purposes, but all of them are unfit for lubricating machinery on account of their resinous nature.

The volatile or essential oils are: The Oils of Amber, Bergamot, Cloves, Lemon, Rose, Orange Flower and many others, all derived from the vegetable kingdom. They are usually more limpid and less unctuous than the fatty oils, with which they mix in all proportions. They are more or less soluble in alcohol and ether, and are sparingly soluble in water, to which, however, they impart their peculiar flavor. Nearly all the volatile oils resist saponification, and do not combine with the alkaline bases to form soapy compounds. They are not used for lubricating purposes.

The mineral Oils and the Petroleum Oils are Hydro-carbons, and belong to the class of volatile and essential oils. They have little affinity for oxygen or moisture. They will not saponify, and they do not ferment or become rancid. The Mineral Oils are derived from bituminous coal and shale by distillation, and have been almost entirely superseded by the Petroleum Oils since the utilization of the latter.

The Mineral Oils obtained by distillation of coal tar, which is the product of the dry destructive distillation of coal at gas works, are chiefly used for dissolving rubber, in the manufacture of the beautiful aniline colors, and in making printing inks, varnishes and paints.

The Petroleum Oils have been placed by nature within easy reach of mankind, and have been of great use for lighting, heating and lubricating purposes. In their natural state they are found in all forms of consistency, from a solid to a thin oily liquid, and from the darkest to the lightest shades of color. This peculiar product of nature is composed of an endless series of Hydro-carbon compounds, from a light, incondensible gas, to a solid body. They are similar in characteristics to the Mineral Oils obtained from coal tar and from shale, but differ materially in their chemical composition.

IV.

OILS AND FATS OF ANIMAL AND VEGETABLE ORIGIN, THEIR CHARACTERISTICS AND HOW THEY ARE OBTAINED.

Lard and Lard Oil.—Lard is the prepared fat of the hog. The fat freed from membranous matter is cut up into small pieces and boiled with water. It is then carefully separated from the water and melted over a slow fire. Lard is a soft, white, unctuous fat, with a faint odor, is free from rancidity and has a bland taste and a neutral reaction. Its specific gravity is about 0.938, or about 20° to 21° by Baumé's hydrometer. Lard is entirely soluble in ether, in benzine, and in disulphide of carbon. It melts at or near 95° F., and when melted it readily unites with oils, wax or resins. Like most animal fats, it consists of stearin, palmitin and olein. Olein, the liquid principle of lard, can be readily separated from the stearin it contains by subjecting it, at a cold temperature, to strong pressure, when the liquid olein is pressed out, leaving the solid stearin, which is principally used in the manufacture of stearin candles. Exposed long to the air, lard

and lard oil will absorb oxygen and become rancid. Lard oil as obtained from lard is a colorless or pale yellowish oily liquid; it becomes opaque at or below the temperature of 32° F. It has a slightly fatty odor and a bland taste. Its specific gravity is from 0.900 to 0.920, or from 22° to 24° by Baumé's hydrometer. It contains varying proportions of stearin, and is much adulterated with cottonseed oil and refined petroleum neutral oils. Lard oil is sold in the market as "Extra Winter Strained" lard oil when obtained by pressure at a cold temperature; as "No. 1" when pressed at a warmer temperature; and as "No.2" when obtained from impurer lard, and by the rendering process. The better qualities are often used to adulterate olive oil.

Tallow and Tallow Oil.—Tallow is obtained from the fat of sheep and oxen. It is prepared by cutting the fat into pieces, melting it at moderate heat and straining through coarse cloth. It is sometimes previously purified by boiling with a little water. Mutton fat is of a firmer consistency, and fuses at a higher temperature than fat from other animals. Tallow is very white, sometimes brittle; it is inodorous, has a bland taste, and is insoluble in water. It consists of about seventy per cent of stearin and palmitin and thirty per cent of olein. It gradually dissolves in two parts of benzine, from which it

slowly separates in a crystalline form on standing. It melts between 113° and 122° F. and congeals between 98° and 104° F. Its specific gravity lies between 0.937 and 0.952 or 18° to 20° by Baumé's hydrometer.

Tallow oil, *i. e.* the percentage of liquid olein in tallow, is obtained by melting the tallow and keeping it in a warm room at a temperature of about 80° to 90° F. for some hours; the stearin which the tallow contains crystallizes in a granular form, and in this state it is placed in canvas or hair-cloth bags and subjected to hydraulic pressure. The olein is thus separated from the stearin. It still contains stearin in various proportions, and the oil is of more or less fluidity, and for that reason its specific gravity varies from 0.911 to 0.915, or from 23° to 24° by Baumé's hydrometer.

Tallow oil is of an almost white color when cold, or, at the most, of a faint yellow tint. It has a slight odor of animal fat. Varying with its quality, it has a flash point of from 475° to 500° F.

Neatsfoot Oil and Horse Tallow Oil.—Neatsfoot oil is obtained from the feet of cows, sheep and horses. The hoofs are trimmed and boiled in water, when the oil collects on the surface and is skimmed off, and is further purified by repeated boiling with water. Neatsfoot oil appears either

as a turbid or a limpid liquid of a yellow-brownish color, has a pleasant odor and a sweet taste, and has little tendency to become rancid; it becomes solid in cold weather from deposition of stearin, has a specific gravity of about 0.912 or 23° Baumé at 60° F., and solidifies at about 32° to 33° F.

Bone fat, bone grease or marrow tallow comes from the shank bones of cows, bullocks and horses. They are either boiled in water, and the rising oil is skimmed off, or they are subjected to steam heat of from 50 to 60 pounds pressure in digesters for from half an hour to an hour. At the end of the operation the fat is drawn off.

Horse tallow, or fat obtained from the rendering of dead horses, is much like the tallow obtained from cows and sheep, and under pressure furnishes an oil which is known in the market as horse tallow oil, and is often sold under the name of "Neatsfoot Oil." It has at 60° F. a specific gravity of 0.915 to 0.980, or 22° Baumé.

Elain or Red Oil.—The oil known as elain or red oil gets its name from the dark reddish color it derives from its contact with the hot iron press plates and the high temperature to which it is subjected in its production by the saponification process with lime or sulphuric acid, or by high steam pressure or by distillation, whereby the fat is decomposed into oleic acid, stearic acid and

glycerin. The fatty acids are allowed to solidfy, and are pressed between hot iron plates, whereby the Red Oil (liquid olein or elain) is separated from the solid stearin. The latter is used in the manufacture of the well-known "Adamantine Candles," and the red oil in the manufacture of soaps and in the compounding of lubricating oils and lubricating for carding wool. By the saponification of solid fats by the lime, sulphuric acid or steam process, the fatty acids are set free from their combination with glycerin, and are allowed to solidify, and are pressed. According to the temperature, more or less stearin and palmitic acids go into the product, and can be separated by distillation. The oil is often semi-solid, resembling tallow grease; the distilled varieties are light brown to deep red; specific gravity at 60° F. is from .899 to .909, or 24° to 25° Baumé.

SPERMACETI AND FISH OILS.

Spermaceti.—The cavities in the upper part of the head of the sperm whale contain an oily liquid, which, after the death of the animal, concretes into a white, spongy mass, consisting of spermaceti mixed with oil. This mass is removed and allowed to separate by draining or pressure in the cold. Common whale oils and the oils from other cetaceous animals contain also small quantities of spermaceti, which on standing they slowly deposit.

Spermaceti is a concrete, fatty substance, a white, pearly, semi-transparent mass of neutral reaction and crystaline foliaceous texture, friable and somewhat unctuous to the touch, slightly inodorous and insipid ; it is insoluble in water, but soluble in the fixed oils ; its specific gravity is 0.945, or 18° Baumé, and it melts at about 122° F. and congeals near 113° F. It is soluble in ether, chloroform, disulphide of carbon, and in boiling alcohol, from which latter, however, it separates in crystalline scales on standing. It is seldom found pure in commerce, but is adulterated with fixed oils. Cetinelaic acid is the main constituent of spermaceti, and is different from oleic acid. Spermaceti also contains small quantities of stearic acid, myristic and laurostearic acids. Pure spermaceti does not produce fatty spots on paper. When old it becomes darker colored and rancid. Different from stearin, spermaceti is not affected by boiling in diluted solution of carbonate of soda.

Sperm Oil—Is the limpid liquid separated from the spermaceti, the spongy mass in the head of the dead sperm whale. It is a pale, yellowish-colored liquid, with a smell of fishy nature, and will, when exposed to the cold, deposit but little solid matter. It is not liable to become rancid, has no corrosive action on metal, and no tendency to dry and become gummy. It retains its

viscosity under influence of heat better than any other oil. Sperm oil is a compound of fatty acids with alcohol radicals, the acids belonging to the oleic acid series. Sulphuric acid gives rise to an increase of heat of some 120° F., and produces a yellowish-brown mass, which distinguishes sperm oil from other fish oils. It differs from other fish oils also by its chemical constitution and its low specific gravity, 0.884 at 60° F., 28° to 29° by Baumé. It is the lightest of all natural oils.

Seal Oil—Is obtained from the blubber of the hooded seal, the barbed seal and the harp seal of the polar regions. The oil is extracted from the blubber the same as from that of the whale, and its properties are similar to the whale oil. Its color varies from a light straw to a brown. It is a strongly odorous oil, of a specific gravity of 0.924 to 0.929, 21° Baumé.

Whale and Train Oils.

These include cod-liver oil, tanner's cod oil from different fish, menhaden oil, porpoise oil, shark oil and whale oil.

The whale and train oils are obtained from the blubber of various species of whale, the polar whale, the humpback whale, the common whale. The blubber varies in thickness from 8 to 20 inches around the body of the whale, and after being cut into pieces, is boiled with water for

about an hour, to liberate the oil from it. The specific gravity of the oil is from 0.920 to 0.931, at about 60° F., or 20° to 22° Baumé.

A large amount of oil of similar character as the foregoing fish oils is obtained from endless varieties of the smaller salt and fresh water fishes, which is used in the manufacture of soaps and lubricating oils, and known in the market as "Fish Oils." They are all oxyhydrocarbons and belong to the class of "fixed oils."

Wool Fat, Degras.—*Wool fat* is obtained by the washings of the wool of sheep. It is the fatty substance produced by the absorption of large amounts of alkali with the feeding of the sheep, thereby producing a secretive matter in the body of the sheep, which is discharged through the skin by transpiration and is deposited in the wool as suint, a quasi-saponified compound of stearic, oleic, and some palmitic acids. Weak alkaline solutions are used to extract this suint from the wool, from which in turn it is obtained by precipitating the alkali with sulphuric acid.

The wool fat when first obtained is a cream-like mass, which requires purification and freeing from moisture. As this is usually accomplished over an open fire, it imparts to the product a dark color.

A considerable amount of wool fat is also obtained from the soapsuds used in the washing

process of woolen goods, by precipitating the alkali with sulphuric acid to liberate the fat.

Degras is also obtained in the process of chamoising skins in the manufacture of chamois leather. The fermentation produced during the manipulation of the skins with fat or fish oils, causes the fat or oil to be split into fatty acids and glycerin. About fifty per cent of the fat or oil employed in the process is recovered in the form of a greasy, fatty mass by wringing and pressing it from the skins. This constitutes the best quality of degras.

A large amount of fatty mass is still retained in the skins, which is obtained by treating them in a warm solution of potassa, whereby the fatty matter is partially saponified, and is separated from the resulting white bath by treatment with sulphuric acid.

An inferior, factitious degras is made from the elain obtained in the manufacture of stearin for candles, mixed with train oils and other fatty matter, by agitation with strong decoctions of tan-bark and partial saponification with alkalies and subsequent separation by means of sulphuric acid.

Degras contains 80 per cent of fatty acids, 10 per cent of glutinous and extract-like substances, 2 per cent of lime, 0.5 per cent of potassa, besides water.

Castor Oil.—Castor-oil is obtained from the

seeds of the castor-oil plant, *Ricinus Communis*, which contain from 50 to 60 per cent oil when separated from the capsules in which they are enclosed. The seeds are roasted over a slow fire and boiled with water, from which the oil is skimmed off; later the seeds are subjected to cold or hot pressure, a better quality and of lighter color being obtained by cold pressure than when pressed warm or extracted with solvents. Castor-oil is the most viscid of all the fixed oils. By long exposure to the air it becomes rancid and thick, and is ultimately transformed into a yellow mass. It has a mild, finally acrid taste, and a nauseous odor, and it is of a somewhat semi-drying character. Exposed to cold a solid, white crystalline fat (margaritine) separates from the liquid portion, and when cooled to 0° F. it congeals to a yellow, transparent mass, which does not liquefy again until the temperature rises to about 18° F. It consists of ricinoleic, stearic, and palmitic acids. Its specific gravity is 0.961, or 15° Baumé. It is soluble in alcohol and in four volumes of rectified spirit. It mixes with fatty oils, but will not mix with mineral oils, unless previously combined with fat or fatty oils.

Olive Oil.—Olive oil is obtained from the fleshy part and the kernels of the fruit of the olive tree of southern Europe, Palestine and Cal-

ifornia. They furnish from thirty to fifty per cent. of oil. The olives are subjected to a gentle pressure, whereby the best qualities of olive oil are obtained. The resulting cake is treated with hot water, from which an inferior oil is skimmed off.

Most of the olive oil of commerce is obtained by allowing the olives to ferment in heaps, and then subjecting them to heavy pressure. The remaining cake or mark is boiled with water, and more oil is obtained of a darker yellowish or brownish-green color. Olive oil is also obtained by extraction from the crushed and dried pulp with hydrocarbon solvents.

Olive oil is of a pale, greenish-yellow color, with scarcely any smell or taste, except a sweetish, nutty flavor. Its specific gravity is from 0.915 to 0.920 at 60° F., or 23° Baumé. Olive oil mixes with disulphide of carbon, benzol and chloroform in all proportions. When cooled down it deposits stearin and solidifies at 25° F. Its boiling-point is about 600° F.

Sunflower Oil.—Sunflower oil is obtained from the seeds of the sunflower, especially from the Black Sea regions. The seeds are roasted and crushed, and the pulp is separated from the wood-like shells. They contain from twenty-eight to thirty per cent of oil. The oil obtained by cold pressure is of a clear yellow color, nearly odor-

less, and of a pleasant, mild taste. Its specific gravity at 60° F. is about 0.9260, or 21° Baumé. It thickens in the cold and solidifies at 60° F. to a white, yellowish mass. It is a very slightly drying oil, and is mostly composed of oleic, stearic and palmitic acids.

Sesame or Gingelly Oil.—Obtained from the seeds of *Sesamum Indicum* of India and from the seeds of the plant cultivated in southern Europe and the Orient.

The seeds furnish from 40 to 50 per cent of oil of a bright yellowish color and agreeably sweet taste. It is much used as a substitute and adulterant of olive oil, and is very similar to it in its characteristics. Its specific gravity at 60° F. is 0.9235, or 22° Baumé.

Cottonseed Oil.—Cottonseed oil is obtained from the seeds of the cotton plant. The seeds contain from fifteen to twenty per cent. of oil, a thickish liquid of a straw-yellow color, with nut-like taste and smell. It is of a semi-drying character, consists of palmitin and olein, and is from twenty-eight to thirty times less fluid than water. Like all the oils obtained from seeds, the latter are first slightly roasted and separated from their outside shells by mechanical power, and the oil is secured by pressure or by extraction with solvents.

The specific gravity of cottonseed oil is 0.9206

at 60° F., or 20° Baumé. It separates palmitin and stearin at about 55° F., and solidifies at about 40° F.

Rapeseed or Colza Oil.—Rape or colza oil is produced from rapeseed, turnips, and other species of Brassica. It is obtained from the seeds by cold and hot pressure, and they yield from thirty to forty-five per cent of oil. The first pressings are known under the name of colza oil; the second pressings are usually sold as rapeseed oil. Colza oil has a pale yellow color; rapeseed oil a greenish-brown color. They are limpid oils, with a peculiar and characteristic odor, and an unpleasant and harsh taste. Exposed to the air, the oil becomes more viscid. Its specific gravity at 60° F. ranges from 0.913 to 0.915, or 23° Baumé. It is a semi-drying and gumming oil.

Hempseed Oil.—Hempseed oil is obtained from the seeds of the *Cannabis Indica* plant. The seeds when crushed have a peculiar odor, and yield by pressure or extraction from thirty to thirty-five per cent of an oil of a greenish-yellow color. The oil remains fluid to 10° F., and thickens when cooled down to 5° F., to a brownish-yellow mass. Its specific gravity is 0.9276, or 21° Baumé, at 60° F., and about 0.9240 at 70° F.

The oil consists of lineolic acid, oleic acid and palmitin and stearic acids. It is somewhat less drying than linseed oil.

Palm Oil and Cocoanut Oil.—Palm oil is obtained from the fruit of the oil palm and the cocoanut palm of tropical Africa, and is known as palm fat, palm butter or palm oil. The oily pulp of the fruit of the oil palm, after being bruised and boiled in water, yields an oil which, when fresh, has a pleasant odor of violets, and assumes in the cold the consistency of butter of an orange-yellow to a dirty, reddish color.

From the dried kernels of the cocoanut (copra) a fixed oil is extracted, which is the cocoanut oil of commerce. The kernels are ground, and the resulting paste is boiled with water. The paste is then submitted to high pressure, whereby a large quantity of milky juice is obtained. This is boiled, and when the oil separates from the water it is skimmed off.

Palm oil or palm butter consists chiefly of stearin and palmitin, both of which have a comparatively high fusing point of about 115° to 120° F., and are preponderant in the solid fat, while olein, which is fluid at 32° F., is the chief constituent of the oil.

The specific gravity is 0.968, or 15° Baumé.

Cocoanut oil is of a bright white color. Its specific gravity is .952, or 17° Baumé.

Almond Oil.—Almond oil is obtained from the kernels of bitter and sweet almonds, the seeds of the almond plant. The sweet almonds contain

more fatty oil than the bitter almonds. The almonds contain from forty-five to fifty-five per cent of oil. For pressing the bitter and sweet almonds are mixed. The oil obtained is a thick liquid, little affected by cold, possesses a purely oleaginous taste and solidifies at 5° F. to a buttery mass. Almond oil is more limpid than olive oil and is thicker than poppyseed oil. It consists almost of pure olein. Its specific gravity is about 0.917 or 23° Baumé.

Poppyseed Oil.—Poppyseed oil is obtained from the seeds of the poppyflower by cold and by warm pressure. It is imported from India and the plant is largely cultivated in France and Southern Europe. The seeds yield about forty-seven to fifty-five per cent of oil of a pale-yellow to a gold-yellow color. It is a clear, limpid oil, with an agreeable taste and a peculiar, slight odor, somewhat like olive oil. Its specific gravity at about 60° F. is 0.9250 or 21° Baumé. It remains liquid until cooled down to 0° F. when it forms a thick, whitish mass. Once solidified by cold, it remains solid to about 30° F., when it begins rapidly to become liquid again. Poppyseed oil is almost as quick drying as linseed oil, and is composed of linolein, oleic, stearic and palmitic acids.

Corn Oil.—Corn oil is obtained from the kernels of the corn (maize) plant, and is almost entirely found in the shells of the kernels.

To separate the shells from the farinaceous part of the kernels, and to make the latter better available for the mashing process, the kernels are first subjected to the malting process. They are then crushed and the shells separated from the farinaceous part by a sifting or centrifugal operation, whereby the parts of lighter specific gravity are easily separated from the heavier ones; nearly eighty per cent of cornmeal, almost entirely free from oily matter, being thereby obtained. Otherwise the oily matter would greatly interfere with the fermentation of the mash, and impart an unpleasant flavor to the alcohol manufactured therefrom.

The hulls thus separated are subjected to heavy pressure, and about fifteen per cent of pure corn oil obtained.

Corn oil is of a light to a gold-yellow color, and has a peculiar, agreeable odor. It is a thickish liquid of 0.9215, or 22° Baumé at 60° F. It is composed of oleic, stearic and palmitic acids, with a small percentage of a volatile oil, and solidifies at about 50° to 60° F. to a quite solid, white mass. It is used as a wool oil, for the manufacture of soaps, and in the manufacture of lubricating oils.

Peanut Oil.—Peanut oil is obtained from the kernels of the peanut. They yield by pressure from thirty to forty per cent of an oil of a light

yellowish, almost white, color, and of an agreeable, particularly nutty, taste and odor. When obtained by extraction the seeds furnish from forty to fifty per cent of oil. The specific gravity is 0.915, or 23° Baumé, at 60° F. The older and last pressed oils have at 60° F. a specific gravity of 0.9202, or 22° Baumé. The oil is more limpid than olive oil, which it resembles much. It is a slightly drying oil. It contains palmitin, olein, stearin and archidic acids the latter being peculiar to this oil.

Mustardseed Oil.—Mustardseed oil is obtained from the seeds of the mustard plant. The seeds yield by pressure or extraction about thirty per cent of oil of dark yellow-brownish color, of a mild taste, and when obtained by pressure, with a very slight odor of mustard. Its specific gravity at 60° F. is 0.917, or 23° Baumé. It solidifies about 18° F., and is composed of stearic, palmitic and a peculiar oleic acid called mustardseed acid.

Nigerseed Oil—Is obtained from the seeds of *Guizotia.* It has a pale yellow color, little odor and a sweet taste. Is more limpid than rapeseed oil and of semi-drying character. Its specific gravity is 0.924, or 22° Baumé.

Linseed Oil.—Linseed oil is a drying fixed oil obtained from flaxseed, which yield about thirty-four per cent of oil. The seeds are roasted before being pressed or extracted, and furnish a light

colored oil of best quality under cold pressure. When pressed warm or obtained by extraction with solvents it is more highly colored and more acid, has a brownish-yellow color, a disagreeable odor, a nauseous taste, and a neutral reaction. Its specific gravity is 0.932 to 0.936, or 20° Baumé. It boils at 600° F., does not congeal at 0° F., and dries and solidifies on exposure to the air and acquires a strong odor and taste.

The drying property of linseed oil resides in a constituent called "linolein," to distinguish it from the olein of the non-drying oils. Spread out in thin layers and exposed to the air, it becomes thicker and resinous, and increases as much as twelve per cent of its weight, owing to the formation of linoxyn by atmospheric oxidation. Boiled with litharge, red lead, lead acetate, manganese dioxide or borate and other chemicals, so-called dryers, it absorbs oxygen still more rapidly, and increases to some fourteen per cent in weight. Its acrimony is due to the presence of a small proportion of an acrid oleoresin. It is much adulterated with other oils when used in the manufacture of printer's ink.

Linseed oil is principally used in the manufacture of paints, by printers and varnish makers, and in the manufacture of soft soaps which are used for cleaning in hotels, office buildings, factories, machine-shops, and engine rooms, and for cleaning automobiles.

Below a few receipts for the manufacture of "German Soft Soap" are given:

In a vessel capable of containing at least three times the quantity to be made, put one part by weight of linseed oil, heat gently and add, in two portions, three parts in all by measure, of liquor of potassa. Boil and stir frequently until the mass becomes clear which will require about five hours for 10 pounds of oil. If during this process the mass becomes too thick to stir easily add a little water.

To make *Green German Soap* allow the soap to become cool; but before it sets work in the coloring matter, which must be previously prepared by boiling finely powdered indigo with water until the color is formed into a thin paste. Twenty grains of indigo boiled with 1½ ozs. of water until the mixture is reduced to about one drachm will answer for soap from four ounces of oil. The soap must not be too hot nor must it be reboiled after adding the coloring matter, or the green will be destroyed.

The liquor of potassa is made as follows: Dissolve one pound of carbonate of potassium in one gallon of water, boil and mix with 13 ozs. of slaked lime washed with water, boil 10 minutes stirring constantly.

Green soap is also made from hemp-seed oil. It should at least contain 5 per cent of free hydrate of potassa.

Transparent Linseed Oil Soft Soap.—Heat linseed oil 150 lbs. and palm oil 10 lbs. together with about 150 lbs. of potash lye of 18° Bé., and effect combination by crutching. When the mass has acquired a pasty consistency it is gradually fitted completely with potash lye of 28° Bé. The boiling lye is prepared by dissolving in caustic potash lye of 50° Bé., 18 per cent. of potash. In the case in question there are required for the saponification of the stock 65 lbs. of 50° caustic potash lye in which 12 lbs. of potash have been dissolved. The lye is then made up to 28° Bé., and about one-half of it is diluted to 18° Bé. in order to obtain a suitable combining lye. When the soap is correctly fitted, it is sufficiently evaporated so that it boils free from froth and breaks short from the paddle without drawing threads. It is then allowed to stand for about 2 hours, best overnight if a larger quantity of stock is used, so that its temperature does not exceed 185° F., otherwise the subsequent filling of potato-flour will form lumps. In the meanwhile the filling is prepared, it being best to heat it somewhat, otherwise the soap would be cooled too much and finally could scarcely be crutched. However, only the solutions used for the filling should be heated prior to adding the potato-flour, and at the utmost to 167° F. The filling consists of 30 lbs. water-glass (silicate of

soda) mixed with 30 lbs. water, 50 lbs. potato flour stirred together with 90 lbs. potassium chloride solution of 14° Bé., and 50 lbs. fitting lye of 28° Bé. The mixture of water-glass and water is first crutched in small portions into the soap, some fitting lye is then added and next the potato flour stirred together with the potassium chloride solution is slowly poured over the soap, the mass being constantly crutched to effect uniform absorption of the filling. While introducing the potato flour filling some fitting lye is from time to time added to prevent the soap from becoming too long and to facilitate crutching. When the filling has been thoroughly crutched in, a sample is taken upon the glass and tested as to the fitting. If the soap is too viscous and soft some lye has to be added so that it becomes sufficiently short and shows the required firmness. When the samples prove the soap to be correctly fitted, it is at once brought into barrels, as when cooled too much it becomes very viscous and can scarcely be ladled. In case the fitting has not been too strong, the soap clears nicely in a few days and notwithstanding the large amount of filling, is quite transparent provided clear filling lyes and pure potato flour have been used.

Transparent Soft Soap in the semi-warm way.— Bring into the kettle 100 parts linseed oil or 60 parts linseed oil and 40 parts cotton oil, together

with 10 parts rosin, and heat. When the rosin is melted allow to cool to 175° F., and then add, whilst crutching, 100 parts caustic potash lye of 22° Bé. mixed with 4 parts soda lye of 38° Bé. When the mass after continuous crutching commences to combine, add at once a solution of 7 parts calcined potash in 21 parts water to prevent thickening. When a complete paste has been formed allow the kettle to stand covered for about one hour to effect thorough combination. Samples are then taken and they should be perfectly clear and short. Small corrections regarding fitting can always be made. When the soap shows the proper constitution it is allowed to cool to 175° F. and filled, a suitable filling consisting of 5 parts potato-flour stirred together with 30 parts potassium chloride solution of 13° Bé. For fitting about 4 to 5 parts potash lye of 28 Bé. are required.

Soft Linseed Oil Soap, with a Yield of 450 per cent.—Heat 190 lbs. linseed oil and 10 lbs. crude palm oil to 190° F. and crutch in 84 lbs. caustic soda lye of 50° Bé. mixed with 126 lbs. water. Combination will take place after crutching for half an hour. Then crutch in 14 lbs. of calcined potash dissolved in 42 lbs. of water. The soap is now entirely clear and can be immediately filled with 100 lbs. potato-flour stirred together with 290 lbs. potash solution of 12° Bé. and 100 lbs.

potassium chloride solution of 13° Bé. The filling, previous to crutching in, should be heated to 145° F. and the soap itself should not be hotter than 176° F. The soap is then fitted with potash lye of 28° Bé., about 80 lbs. of it being required for this purpose, until a sample upon the glass is again short and firm.

A Cutting Compound.—Glucose flour mixed to a paste with the assistance of heat, and thinned out with linseed oil; then mixed with water.

It can also be made with linseed and fish oils and neutral petroleum oil.

Rosin, Rosin Oil and Turpentine.—Rosin is obtained by distillation of the crude turpentine obtained from several species of pine and fir trees, especially the pine trees of the States of North and South Carolina and Georgia.

The crude turpentine-resin is distilled with water, and yields about one-fourth of spirits of turpentine, the remainder being the common rosin of commerce.

Rosin is a semi-transparent solid and brittle product of smooth and shining fracture, of a yellowish-brown, sometimes almost black, color. It has a somewhat acrid and bitter taste, and is insoluble in, and rather heavier than, water.

Rosin melts at about 275° F., and is completely liquid at 306° F. It is soluble in the fixed and in volatile oils. Rosin distilled by itself yields rosin oil.

The first distillate below 674° is the lighter, at a specific gravity of about .987, or 12° Baumé, at 60° F., and that over 675° F. being the second and heavier oil at a specific gravity of about .981 to .985, or 12° Baumé, 60° F. Rosin oil readily resinifies by absorption of oxygen, and is much used as an adulterant of linseed oil and in the manufacture of printer's inks. Rosin oil consists of sylvic and pinic acids. When distilled with superheated steam, rosin yields benzol and toluol.

Oil of turpentine is also obtained by distillation of the cones of the pine trees. Its specific gravity is about 0.953 at 60° F., or 25° Baumé.

Pine tar is obtained by charring the wood of pine and other coniferous trees.

Deodorized rosin oil is that freed from the "spirits" by fractional distillation.

Rosin or pine oil (kidney oil) is a somewhat thickish fluid of a brownish-yellow color, aromatic, turpentine-like odor and taste. Its specific gravity is about 0.985 at 60° F., or 12° Baumé. At that temperature it is about ten times thicker than water, becomes whitish turbid at about 16° below zero F., and solidifies at about 20° below zero F. It is a slow-drying, gummy oil.

Glycerin.—Glycerin, also called the sweet spirit of the fatty oils and fats, is a trihydric alcohol,

and is not found readily formed in the fatty matter. All fats and fatty oils are considered glycerides, that is, compounds of fatty acids with a weak base called glyceryle. By the process of hot saponification the stronger alkaline bases unite with the fatty acids to form soapy compounds, thereby separating and setting the weaker base, "glycerin," free, and from ten to twelve per cent of it is thus obtained. Glycerin is also obtained from fatty matter by the action of superheated steam.

Under cold treatment of fatty matter with alkline bases, the latter unite with the fatty acids and form oleates, stearates and palmitates of soda or potassa, but no glycerin.

Glycerin is a water-white, viscid liquid. It has no odor, but a very sweet taste. It boils at 550° F., is not volatile at ordinary temperature, but will vaporize at 212° F. When mixed and boiled with water it readily absorbs water from the air, and will mix with water in all proportions. It is miscible with alcohol in all proportions, but is insoluble in petroleum and benzine. A mixture of nitric acid and sulphuric acid forms with it "nitro-glycerin," a most powerful explosive.

V.

CLARIFYING, REFINING AND BLEACHING OILS AND FATS.

THE clarifying and bleaching process must necessarily vary, as some oils may be more or less colored or mixed with impurities than others. The animal oils and fats require bleaching or clarifying only when obtained from impure material or offal. The vegetable oils, however, are generally more or less colored and permeated with vegetable and albuminous matter. In many cases it will suffice to blow hot dry air of a temperature of from 120° to 130° F. through the oil to remove the undesirable color and impurities. Others may be bleached by exposure to the sunlight in bright, shallow vessels, or by agitating the oil mixed with animal charcoal, at a temperature of about 120° F., and then filtering it. In many cases, however, one or the other of the following processes may be required:

Oils are clarified by the admixture of from five to ten per cent of fuller's earth, stirring well at a temperature of 140° to 150° F.. The mixture is then allowed to rest and settle. The

fuller's earth carries down with it all impurities in suspension, and the sediment can be treated with benzine to recover any oil remaining mixed with the fuller's earth.

Oils are also refined by treatment with sulphuric acid, which destroys all extraneous vegetable matter. The oil is heated to about 110° to 115° F., and from one to two per cent of sulphuric acid, usually previously diluted with an equal proportion of water, is added, with constant agitation for about half an hour. It is then allowed to rest and settle for about twenty-four hours. From twelve to fifteen gallons of water, heated to about 150° F., to every twelve gallons of oil, is then stirred with the oil and the oil allowed to rest and settle for a few days, when it is drawn off and washed with water to remove all traces of acid.

Oils and fats, especially cottonseed oil, are also refined with caustic soda, which, like acid, destroys all extraneous vegetable, mucilaginous and resinous matter, and all acidity in the oil. A caustic lye of from fifteen to twenty degrees Baumé is used for cottonseed oil, from eight to twelve degrees for most other fatty oils, and a lye from five to six degrees strength is generally found sufficient for cocoanut and like oils, and often a lye of from one-half to one per cent strength only will be sufficient for the purpose.

Oils containing much of free fatty acids can be effectively treated with weak solutions of caustic or carbonate of soda, or with milk of lime or magnesia, and the oil filtered from the lime and magnesia soap thereby formed.

Strong solution of chloride of zinc, from one to two per cent of the oil, is also used. It destroys and precipitates all albuminous and vegetable matter suspended, without injury to the oil, but is more expensive than sulphuric acid.

It is advisable to avoid treating oils to be bleached with too large proportions of chemicals at once, as repeating the operation with smaller proportions will generally secure better results.

Oils can be bleached and thereby also deodorized with chlorine, a powerful bleaching agent.

The oil is heated to a temperature of about 140° to 150° F., and a solution of chloride of lime, "bleaching powder," in the proportion of about one pound to a thousand pounds of oil, is mixed with the oil. Hydrochloric (muriatic) acid is then added in about twice the quantity of the bleaching powder used, and the oil is thoroughly agitated. It is then allowed to settle, and the oil and fat are then drawn off. Chloride of potassa or peroxide of manganese, with hydrochloric acid, can also be used in the same manner as the chloride of lime.

Oil can also be deodorized by shaking 1,000

parts of it with 120 parts of water, holding in solution 3 parts of permanganate of potassa, keeping it warm for some hours, and then filter. For bleaching lard oil, palm oil, and similar oils and fats, the bichromate of potassa process is much used. The oil or fat is heated to a temperature of about 130° to 140° F., and a concentrated solution of bichromate of potassa in the proportion of about 10 to 12 pounds of the bichromate to a thousand pounds of the oil or fat is added and thoroughly stirred into the oil. Hydrochloric acid in the proportion of from two to three per cent of the oil is then added, and the whole well stirred for from ten to fifteen minutes. The oil, which at once assumes a reddish-green color soon changes to a pale-green one. Boiling water is then added, and the agitation continued for a few minutes more, or live steam is blown through the oil and then allowed to settle. The oil is then drawn off and washed with water to remove all traces of acid.

Degras is bleached and deodorized in the following manner: The degras is melted by heating with live steam and thoroughly agitated by paddling, or blowing with air. A solution of bichromate of potassa in water—one pound or more of bichromate of potassa for a hundred pounds of degras—is added, and after agitating for a few minutes a solution of two pounds of sul-

phuric acid, previously diluted with six pounds of water, is poured in. Next three pounds of black oxide of manganese are added and agitated for half or three quarters of an hour. The blower is then turned off and the acid and water allowed to separate, and are drawn off from underneath the fat. The grease is now sprayed with hot water, which is again allowed to settle, and is drawn off. This is repeated until all sour taste is removed. When cold, stir thoroughly and allow still adhering water to run off.

Tallow and other fat can be cleaned and bleached by boiling some fifty pounds of the fat with about five to ten pounds of alum dissolved in about ten gallons of water for about an hour, constantly stirring and skimming. Draw off the clear fat and add one pound of sulphuric acid diluted with three pounds of water. Boil and add some eight ounces of bichromate of potassa; continue boiling, and if necessary add a little more acid; then allow to settle, draw off and wash with boiling water; finally spray with a little cold water to accelerate the clearing of the fat.

To clean and bleach and deodorize train oil boil with salt water, consisting of about one-fourth its weight of sodium chloride (common salt), and stir briskly for about half an hour; then allow to settle, draw off the oil and mix with a decoction

of nutgalls. After briskly stirring for about fifteen minutes or so, add about four ounces aqua fortis (nitric acid) to every hundred pounds of the oil; stir for a little while longer and allow to settle; draw off the clear oil and wash with water.

Grease is bleached by melting and agitating with about three per cent of sulphuric acid and two per cent of a saturated aqueous solution of bisulphite of soda. The mixture is then run into a narrow cylindrical vessel and violently agitated with dry steam for half an hour, and is then run off and allowed to cool slowly, and while still fluid the fat is drawn off without disturbing the sediment. It is again agitated with steam and about 20 per cent water and left standing to separate and harden.

Action of Fats and Oils on Metals.—Mineral lubricant has no effect whatever on tin and copper, attacks brass least and lead most. *Olive oil* attacks copper most, zinc least. *Rape oil* does not act on brass and tin, while copper is attacked most by it, and iron least. *Tallow oil* acts most vigorously on copper and least on tin, while *lard oil* attacks copper most and zinc least. *Cotton-seed oil* acts most vigorously on zinc and least on lead. *Spermaceti oil* attacks zinc most and brass least. *Whale oil* has no effect whatever on tin, least on brass, and most on lead, while *seal oil* attacks brass least and copper most. On the other hand,

the experiments have shown that *iron* is most vigorously attacked by tallow oil and least by seal oil, while rape oil has no effect on it whatever. *Tin* is not attacked by rape oil, only slightly by olive oil, and most by cotton-seed oil. *Lead* is least acted on by olive oil and most vigorously by whale oil, while lard oil and spermaceti oil have almost the same effect as whale oil. *Zinc* does not appear to be attacked by mineral lubricants, while lard oil acts on it least and whale oil most. *Copper* is attacked least by spermaceti oil and most by tallow oil.

VI.

MINERAL OILS.

THESE oils are obtained by distillation from Scotch shale, a black, somewhat flaky mass of homogeneous structure, with an irregular, glossy surface. It is usually soft enough to be cut, and when ignited burns with a flame. The better qualities yield from thirty to thirty-three per cent of oil; the poorer grades are stony and slate-like and produce little oil.

When submitted to distillation in large vertical stills, an uncondensable gas and water containing a large proportion of ammonia first come over; then a crude oil of a thickish dark reddish brown, with a peculiar odor and of a specific gravity of from 0.865 to 0.890, or 32° to 27° Baumé, is obtained. This is again subjected to distillation, and naphtha and light-colored oil, which gradually becomes darker, are obtained. Solid paraffine begins to show itself, followed by a thick, brown oil, and finally coke is left in the still.

The oil is treated with sulphuric acid and with

a solution of caustic soda. When again distilled the oil yields a light spirit known as green naphtha, a light oil known as "second run oil," and a dark-colored, heavy oil, known as "green oil," and coke is left as residuum in the still.

The naphtha is treated with sulphuric acid and solution of caustic soda, and is separated into several grades of illuminating oil.

The "green oil" is subjected to a freezing temperature, and paraffine wax is obtained from it by pressure. The solid paraffine wax obtained is about twelve to fifteen per cent. The remaining oil is known as "paraffine oil," and was formerly used in the manufacture of lubricating oils.

The specific gravity of the light oils from shale is about 0.730 to 0.760; that of the heavier oils is about .810 to .820. The oil from the paraffine pressings has a specific gravity of about 0.872 or about 30° Baumé.

Shale oil is treated with a small proportion of sulphuric acid and caustic soda, about one per cent, and redistilled, yielding the following grades of illuminating oils:

No. 1, best, with a specific gravity of 0.800 and 100° F. flash point.

No. 2, first quality, with a specific gravity of 0.810 and 103° F., flash point.

No. 3, second quality, with a specific gravity of 0.815 and 120° flash point.

No. 4, lighthouse oil, with a specific gravity of 0.820 and 160° F., flash point.

No. 5, marine sperm oil, with a specific gravity of 0.830 and 230° F., flash point.

A fuel oil of about 0.840 specific gravity is left.

Steam is used in the still and controls the distillation; it lowers the temperature of the distillate and facilitates the passing of the vapors from the still.

The mineral oils have been entirely superseded by the petroleum oils since the discovery and utilization of the latter.

Tar Oils.

Tar oils are obtained from tar, being the result of the destructive distillation of wood and bituminous coal.

Wood is distilled in iron retorts and in covered heaps or pits to obtain thereby the resulting charcoal. The lighter products of the distillation are wood alcohol, naphtha and pyrolignic acid, the latter being used in the manufacture of acetic acid and other acetate products. The tar obtained by the destructive distillation of wood is re-distilled and wood-tar oil is obtained, from which picric acid is made by treatment of the oil with nitric acid. The oil is also used in the manufacture of leather oils, medicinal soaps and ointments. Creosote, another product obtained by the distillation of

wood-tar, is in its chemical composition very different from the carbolic acid, often misnamed creosote, obtained by the distillation of tar from the destructive distillation of bituminous coal at the gas-works.

By the distillation of tar from the gas-works we obtain benzol and coal-tar oil. This benzol is a product of far different chemical composition than the benzine obtained from petroleum, although often confounded with it. Benzol, when treated wih nitric acid, is converted into nitro-benzol (or myrbane oil), which has a strong odor, like oil of bitter almonds. This oil is much used in perfumery and for scenting soaps and greases, for lubricating, and for deblooming petroleum oils.

When acted upon with nascent hydrogen this nitro-benzol or myrbane oil is converted into aniline oil, from which the many beautiful aniline colors are made by the use of powerful oxidizing agents. Coal-tar oil, too, contains large amounts of aniline oil, which is separated from it by agitation with strong mineral acids, which combine with the aniline oils.

Coal-tar is also used in the manufacture of coal-tar paints for painting roofs, smokestacks and iron structures. The product left in the still is the well known asphaltum, extensively used in roofing and for paving purposes.

VII.

PETROLEUM OILS.

WHEREVER and however nature carries on its mysterious process of producing the various grades of petroleum found all over the globe, the lighter and the heavier grades, the brighter and the darker colored ones, all are found in shallow places, above ground or near the surface, or deep down in the bowels of the earth, those found lowest being generally of lighter consistency than those found on or nearer to the surface. They are all hydrocarbon compounds of like characteristics, differing only in their specific gravity, in their color, odor or in purity. The deposits found above ground or near the surface, which are almost solid or are liquids of heavy specific gravity, appear to be the result of evaporation of their lighter constituents or of a gigantic filtering process, by which the liquid constituents have percolated to a lower stratum, leaving the heaviest ones retained where they are found in an upper stratum or on the surface, as Ozokerite wax.

The petroleum oils of Pennsylvania, in Ve-

nango, Clarion and Butler counties, in Warren and McKean counties, vary in color from light amber-yellow to dark black, and vary in specific gravity from 30° to 55° Baumé; from thick lubricating oils to nearly pure benzine. Franklin county oils are celebrated for their fine bright, dark ruby color, their fine lubricating quality and excellent cold test, which makes them valuable as lubricants on refrigerator machinery.

The Ohio crude oils containing sulphur and having an unpleasant sulphurous odor, are desulphurized during the process of distillation by placing a desulphurizing chamber between the retort and the cooler. This chamber is separately heated and is filled with iron oxide, copper sulphate, porous lime coke, or other desulphurizing agents, and hot air can be driven through the oil. When a temperature of 130° F. is attained in the desulphurizing chamber, the still is fired and the heating of the chamber is increased to prevent the passing vapors of the oil from condensing in the chamber before passing through the cooler. Introducing nascent hydrogen into the still or the desulphurizing chamber, and its vapors mingling with those of the distilling oil, improves the color and odor of the distillate and changes the product into one of lighter gravity and purer odor.

Aluminium chloride also is used to desulphurize Ohio petroleum. One hundred parts of the oil

are heated and while agitated, 0.8 part of aluminium chloride is gradually added, whereby a little muriatic acid and much sulphureted hydrogen are evolved. When no more gas is eliminated, the oil is allowed to cool and is drawn off from over the aluminium residuum and washed with water and soda lye, and is distilled with the addition of a little lime.

In order to enhance the value of the various forms of petroleum and to make them adapted and available for their manifold uses in the market, they are either purified, condensed or distilled. Some require only straining or settling and exposure to the atmosphere, for a period of time, to vaporize all traces of inflammable, light hydrocarbon compounds and to settle all gritty matter and impurities, to make them serviceable for lubricating purposes. Others are condensed and the lighter vapors driven off and settling of gritty impurities is effected by application of steam heat. The greater bulk, however, is subjected to distillation, in order to separate the different grades of hydrocarbon compounds from each other and thus obtain various useful products.

Distillation of Petroleum.

When crude petroleum is subjected to distillation and the uncondensable gases and moisture have gone over, a series of light hydrocarbon

compounds known as "benzine" are first obtained, about 15 per cent. Then a number of grades of burning oil, known as "distillates," come over and are collected separately. They are treated and bleached and freed from adhering scorched impurities with sulphuric acid and solutions of caustic soda. From 50 to 60 per cent of these oils is obtained and the remaining residuum oil forms the basis for the petroleum lubricating oils.

The lighter products of the distillation, the crude benzine, are subjected to redistillation with steam heat and are separated into their respective degrees of specific gravity and characteristics required by the manifold demands for their use. They are purified, deodorized and bleached by treatment with chemicals and are sold as naphtha, gasoline, benzine, and under many fancy names.

The "distillates," which are next obtained, are likewise purified and bleached by treatment with sulphuric acid and solution of caustic soda and by exposure in bright and shallow tanks to the bleaching influence of sunlight. Numerous grades of distillates are produced by being carefully separated from each other during distillation.

The proceeds of distillation at specific gravities are the benzine series, from the highest gravity (the first distillate obtained) down to about 56°

to 58°, standard white or export oil of 110° F. flash or 70° Abel test, from 56° to 54° and then from 42° to 39°. Water-white oil, 120° flash or 150° fire test, the legal test of Ohio and now the generally accepted test of most states, from 54° to 46°, or until the distillate begins to show color. Prime white oil, 150° fire test, from 46° to 42°, and headlight oil, 175° fire test, from 46° to 39°.

In case 110° standard white and 175° headlight oils are not desired, there will be but two separations between 56° and 39°, viz., 150° water-white oil and 150° prime white oil, the necessary fire test being obtained by driving off the lighter vapors by redistillation in a steam still, or by steaming and spraying in an agitator or open tank, but preferably in a steam still, in which case what is known as a "Straight Run" (distillate from 58° to 46°) water-white oil, the requirement of almost any State law as to flash or fire test, can be made. These gravity separations are not absolute, but flexible within a few degrees, dependent upon the nature of the crude oil used and the grade of oil desired.

The continued distillations from 39° down to 29° constitute the neutral distillates, and are divided by separation into what is known as 300° F. or mineral seal oil and 34° to 36° neutrals, or by redistillation into a small percentage of prime white or headlight, 300° or mineral seal, 34° to

36° neutral, and a residual oil known as "Spindle Oil," of 30° to 32° Baumé, possessing considerable viscosity.

If the distillation from the crude still is carried from 29° to 20° and the product afterwards redistilled, the residual of the second distillation will be the commercial red oils of high viscosity and gravity of from 30° to 23°.

The residual oil in the crude still at 24° to 19° is usually pumped hot into a tar-still and the distillation continued down to coke, producing the paraffine distillates hereafter to be described.

The carbonaceous residuum or coke left in the still is used in the manufacture of carbons for electric lighting.

The neutral oils are purified and bleached by treatment with sulphuric acid and solution of caustic soda. They are deodorized by air-blast and their fluorescence skillfully removed with chemicals. They are largely used for adulterating the more costly animal and vegetable "fatty oils."

The crude paraffine oils hold crystalline paraffine wax in suspension, produced by the disintegration of hydrocarbon compounds during the process of distillation. It is extracted from the oil by freezing and pressure, and is purified by treatment with sulphuric acid and caustic soda while being kept in a liquid state by heat. It is

bleached with benzine and then cast into solid blocks.

Paraffine wax is largely used in waterproofing fabrics, for insulating, and in the manufacture of candles and matches, and numerous other products. The paraffine oil left after separation from the wax is treated with acid and solution of caustic soda and is filtered through animal charcoal. It is used for lubricating and is known as "Golden Machine Oil." The paraffine oils of varied degrees of specific gravity form the basis for many engine lubricating oils and are compounded with fatty oils in endless proportions.

In order to make the residuum oil left in the still, after distilling off the burning oils, directly useful for the purpose of lubricating engine cylinders, the oil is put into tall vessels, surrounded by steam, and the impurities, produced by the scorching influence on the oil against the heated bottom and sides of the still during the process of distillation, are allowed to settle. This kind of residual is sold under the name of "Steam Refined Cylinder Oil."

Crude oil of proper character will also produce a good cylinder oil by introducing steam during distillation in the bottom of the still, sufficient to prevent scorching or carbonizing by running down to 23° to 27° in the still. The lower the gravity the higher the fire test. If run slowly

and carefully and strained while hot, a second steaming and settling will not be necessary to produce a good steam-refined cylinder oil.

Crude oil not suited for cylinder oil produces a black lubricating oil or "West Virginia oil," as it is sometimes erroneously called.

Residuum oil is also filtered, while hot, through animal charcoal, to give it a brighter color and deprive it of all charred impurities held in suspension. As such it is known in the market as "filtered cylinder stock." Repeated filtration produces the products well known under the names of "vaseline," "cosmoline," "petrolatum," and many other fancy names. They are all compounds of paraffine wax in an amorphous state, to which the original crystalline wax of the residuum oil has been converted by chemical action during the repeated filtering through animal charcoal.

Petroleum Oils for Lubricating.—Petroleum oils for lubricating should have a flash point above 300° F. On general principles, the most fluid oil that will stay in place should be used; the oil that possesses the greatest adhesion and the least cohesion is the best. These conditions are possessed first by the petroleum oils and second by sperm oil, neatsfoot oil, and lard oil. For light pressure and high-speed machinery, mineral oils of a specific gravity of 30° Baumé and 350°

F. flash point, mixed with sperm oil, olive oil or rape oil, are used. For ordinary machinery, oil of a specific gravity of 25° to 29° Baumé, with a flash point of 350° to 400°F., mixed with lard oil, neatsfoot, tallow, or with vegetable oils is used. For use on spindles in cotton mills, oils of 360° are quite safe, and the flash point for cylinder oil should not be below 500° F.

For gas engines and gasoline engines, a pure hydrocarbon oil of high vaporizing point, about 260° F., a flash point of 430° F. and a fire test of 550° F., is considered best.

A compound of lard oil and petroleum burning oil, used in lanterns as signal oil, should not contain less than 40 per cent of prime lard oil and have a flashing point not below 200° F., and a burning point or fire test not above 300° F.

Uses of Petroleum.—Petroleum is one of the greatest gifts bestowed by nature on mankind. Gasoline derived from petroleum oil enables us to travel in automobiles, with airships and motor boats. The burning oil from petroleum supplies light and heat to the humblest cottage. The lubricating oils derived from it lubricate the endless number of machines used in industrial working, and enables us to travel by steam and electric power over land and water. The neutral oils and the paraffin oils are utilized in the manufacture of the "Valve-Oleum" oils, well known

as mineral castor oils and mineral gelatines, and the many grades of vaseline are used to give medical relief to suffering mankind.

The "Dieterichs Kafer-Oil Liniment" and the carbolated "Kafer-Ointment," two reliable household remedies in use for many years and recommended by thousands, are products of petroleum compounds.

The paraffin wax derived from petroleum oil serves for saturating paper, for water-proofing, and in ironing fabrics, for covering to protect canned fruits, for insulating electric currents and for many other uses.

The residuum oils left from the distillation of petroleum oils and the heavier natural ground oils are used as fuel oil for heating steam boilers and stills in place of coal.

Coke, the last of the products from petroleum oils, is utilized for the manufacture of carbon candles, for electric lamps and many other electrical appliances.

Deblooming Petroleum Oils.—For adulterating animal or vegetable fatty oils with petroleum, neutral oils are debloomed, which means freeing them from their fluorescent appearance, by refining them with chromic acid, or more readily as follows:

The oil is heated to about 140° to 160° F., and nitro-naphthaline, binitro-benzol or binitro-toluol,

known as myrbane oil, is added and well stirred into the oil in proportions of about three ounces to from twenty to twenty-five gallons of oil with a slight bloom, and from fifteen to twenty ounces for oil with heavier bloom. No material influence is thereby exerted on the the oil and no tendency of the bloom to reappear remains.

For test, boil one part of the oil with three parts of a ten per cent solution of potassium hydrate in alcohol for one or two minutes. If either of the nitro-compounds is present, a blood or violet-red coloration will be produced. A pure oil is changed by this test to a yellow color only.

Deodorizing Petrol Oil.—Kerosene oil and benzine can be freed from their bad odor as follows:

The kerosene oil is mixed with chloride of zinc and then poured into a vessel which contains burnt lime, and after stirring well, is left standing for some time, to settle, when the pure kerosene is drawn off.

The benzine is mixed and well stirred with a mixture composed of alkali manganese oxide, some water and sulphuric acid. After some twenty-four hours' standing the benzine is drawn off again, treated with permanganate and soda in water.

Benzine and kerosene oil can also be deodorized and bleached, and their specific gravities improved, by a treatment with nascent or fixed hydrogen gas. One per cent of amyl acetate will also deodorize petroleum oils.

VIII.

MANUFACTURE OF LUBRICATING OILS.

THE manufacture or compounding of lubricants is manifold. For cylinder oils, mineral or petroleum oils of a specific gravity of about 27° Baumé and a fire test of about 550° F., either alone or with additions of from one to ten or fifteen per cent of animal or vegetable oils, are used. The fatty oils that such lubricants are generally compounded with are lard oil, neatsfoot oil, tallow oil, linseed oil, cottonseed oil, rapeseed oil, or degras. For heavy pressure and low-speed machinery, lard, tallow and other compounded greases, either by themselves or mixed with graphite (plumbago), mica and soapstone (talc), are used.

On account of their great propensity for absorbing oxygen, the fatty oils are now seldom used alone for lubricating, but are more or less compounded with petroleum oils. The viscosity of lubricating power of spindle oils and red oils depends on the amount of amorphous parraffine wax they hold in suspension, which, however,

loses much of its consistency under the influence of frictional heat.

To give petroleum oils a viscous consistency they are often compounded with proportions of oleate of lead (lead plaster) dissolved in the oil while heated to from 140° to 160° F. One to two per cent of unvulcanized caoutchouc or rubber are also often dissolved in the oil, heated and stirred together until thoroughly diffused. Soap in various proportions and thoroughly dried is also compounded in petroleum lubricating oils by heating and stirring until fully dissolved and diffused and the oil has become perfectly bright and clear. Four ounces of soap to a gallon of oil will cause it to gelatinize at 60° F., and one pound of soap to the gallon will convert it into grease.

For cylinder oil, steam-refined residuum stock or medium filtered cylinder stock is heated to about 130° to 140° F. and stirred or blown until free from moisture and scum, and from one to five gallons, or even more, of tallow oil, lard oil, neatsfoot oil, rapeseed oil, olive oil, or fish oil added to each barrel of stock. To give common filtered stock a better cold test for winter use paraffine oil or red oil, of 28° to 30° Baumé is added in the proportion of about five gallons, more or less, to a barrel of stock.

Degras (woolfat) is also used in the compounding of this kind of cylinder oils, in the proportion

of from one to three gallons to a barrel of filtered stock. The degras should be previously heated and all arising scum removed before mixing with the cylinder stock.

Castorbean oil, well heated together with yellow lard grease, and combined with well heated cylinder stock, is compounded for cylinder lubricating oils.

For engine and machinery oil, paraffine, spindle or red oils of a gravity from 28° to 33° Baumé, are compounded and well stirred together with a few gallons of filtered stock to improve the viscosity of the lighter petroleum oils.

The compounding of petroleum with fatty oils, for engine and machinery lubricating purposes, should always be conducted at a temperature of about 140° to 160° F. and with a thorough mixing, else the oils, being only a mechanical, and and not a chemical, mixture, when resting will separate from each other, on account of their differences in specific gravity. This explains the fact that such compounded oils, when imperfectly mixed, when kept in tanks and gradually drawn off by the faucet placed near the bottom, appear at first to be of a satisfactory consistency, but drawing towards the end are complained of as being too thin and deficient in body, the oil in the course of time having separated and the lighter oil having gradually risen to the top.

Crude rosin oils are refined by distillation and the resulting products are treated and bleached with chemicals and skillfully deodorized so that not the slightest odor would betray their origin, unless partially decomposed under application of heat. As the rosin oils are of a very low gravity, they are used in the compounding of lubricating oils to give the petroleum oils a body and to pass the lighter oils off for lubricating oils of lower gravity and greater viscosity. Lard oils and other fatty oils are often adulterated with petroleum oils, and to reduce the lighter gravity of the latter, have been compounded with such deodorized rosin oils, to equalize the specific gravity of such compounded oils to that of genuine lard oil.

Lubricating oils have also been made by avaricious and ignorant compounders by mixing heavy rosin oils with lighter petroleum oils or even simply dissolving common rosin in them, in the proportion of from two to four pounds to a gallon. The viscosity or body of such compounded oils appears deceptively superior to some of the best lubricating oils, but like all rosin oils and rosin and rosin-oil mixtures, which form resinous deposits under the influence of frictional heat or on exposure to the air, they are entirely unfit for lubricating purposes, as they gum up the machinery and retard the motion by their sticking propensities.

Receipts of Lubricants used in Germany. Cohesion oils.—A more or less viscous fat serves invariably as the basis of these oils. Rape oil is most frequently used, more seldom train oil, and, to decrease the degree of fluidity, tallow, palm oil, neatsfoot oil, or another solid fat is generally added. Besides these fats all these oils contain rosin oil in varying quantities, from 8 to 20 per cent of the amount of fat used. The peculiarly characteristic viscosity of these oils is imparted to them by the addition of up to 15 per cent of the fat used of American rosin. The larger the quantity of the latter, the greater the cohesion of the lubricant will be. It is, however, not advisable to use more than 15 per cent. of rosin, especially if the lubricant is to be used also at a lower temperature. Some cohesion oils contain coloring or odoriferous substances, or both. As lubricants these substances are entirely indifferent, and are only added to cover the other constituents and render their detection more difficult.

The preparation of cohesion oils is quite simple. The rape oil is slightly heated in a kettle and the determined quantity of solid fats (tallow, palm oil, etc.) is added. In another kettle which must be especially protected to prevent ignition of the contents, the rosin oil is heated almost up to the boiling point and the rosin, previously broken into small pieces, is gradually

added, a fresh portion of it being thrown in only after the one previously introduced is completely dissolved. To prevent the rosin from burning to the bottom of the kettle, solution should be assisted by stirring. When all the rosin has been dissolved in the rosin oil, the solution is ladled, whilst stirring constantly, into the kettle containing the oil and fat mixture, stirring being continued until the mass begins to get viscous.

Cohesion oil for rapidly running, heavily loaded axles.—Crude rape oil 190 parts, purified tallow 10 parts, rosin oil 20 parts, American rosin 24 parts.

Cohesion oil for light axles.—Crude rape oil 192 parts, purified tallow 8 parts, rosin oil 16 parts, American rosin 16 parts.

Lubricants for Threshing Machines consist of mixtures of mineral oil with refined rape oil, for instance, 400 parts by weight of mineral oil of 0.906 to 0.908 specific gravity and 50 parts by weight of rape oil.

Automobile Oil.—I. Refined rape oil 5 parts by weight, neatsfoot oil 5, white vaseline oil 3.

II. Refined rape oil 2 parts by weight, white vaseline oil 6.

Mineral Oil Lubricants.—Melt the solid constituents, then add the oil and mix thoroughly.

I. *Melting point 120° F.*—Tallow ½ part, ceresin ½ part, filtered cylinder oil 4 parts.

II. *Melting point 150° F.*—Ceresin 1 part, tallow ½ part, filtered cylinder oil 1½ parts, mineral oil of 0.903 to 0.907 specific gravity, 2 parts.

III. *Melting point 184° F.*—Cosmos cylinder oil 2 parts, cotton oil 1 part, oleic acid 1 part, ceresin 1 part.

IV. *Melting point 215° F.*—Petroleum jelly 1½ parts, castor oil 1 part, aluminium oleate 1 part, ceresin 1½ parts.

V. *Melting point 220° F.*—Petroleum jelly 1 part, seal oil 1 part, ceresin 1½ parts.

Sewing machine Oil.—I. Mix intimately 10 parts by weight of pure neatsfoot oil with 190 parts by weight of white vaseline oil.

II. Refined rape oil 25 parts by weight, white vaseline oil 15 parts by weight.

III. Refined rape oil 10 parts by weight, white vaseline oil 100 parts by weight.

Lubricants for Ice Machines.—Mix 127.5 parts by weight of machine oil of 0.915 specific gravity with 22.5 parts by weight of rosin oil.

Lubricant for Compressors consists of a mixture of 30 parts by weight of refined rosin oil and 170 parts by weight of mineral oil of 0.912 to 0.915 specific gravity.

Lubricating Oils with Rosin Oils.—I. Refined rosin oil 100 lbs., yellow rosin oil 600 lbs., rape oil 100 lbs.

II. Refined rosin oil 400 lbs., pale paraffine oil 300 lbs., cotton oil 300 lbs.

III. Refined rosin oil 100 lbs., pale rosin oil 300 lbs., cotton oil 120 lbs.

IV. Refined rosin oil 200 lbs., olive oil 100 lbs., rape oil 150 lbs., rosin oil 200 lbs.

Thickened Oils.—Rapeseed oil, cottonseed oil and other fatty oils can be thickened and their viscosity increased by heating them to from 160° to 170° F. and forcing or blowing air heated to a like temperature through the oil for several hours. The propensity of the fatty oils for absorbing oxygen allows of turning them by this process into heavy, viscous oils, which are largely used to impart greater viscosity to lighter petroleum oils used for lubricating purposes.

Blown rapeseed oil has a specific gravity of 0.967 at 60° F., or 15° Baumé.

Blown cottonseed oil has a specific gravity of 0.974 at 60° F., or 14° Baumé.

IX.

"VALVE-OLEUM" OILS.

THE fatty oils and fats are composed of either oleic, margaric or palmitic and stearic acids, which, when treated with caustic soda, form compounds soluble in water. Precipitated with mineral salts, such as sulphate of alumina, magnesia, lime or acetate of lead, etc., they form insoluble compounds, which are only soluble in other fatty oils or petroleum oils. In this state the oils possess uncommon lubricating power, without the injurious effect the otherwise free fatty acids would exert on the metal of which the machinery requiring lubrication is made. They form the foundation of the manufacture of the "Valve-Oleum" Oils ("Valve-Oleum" is their trade-mark), patented by the author, and they combine the excellent lubricating qualities of fatty oils with the great cleanliness and diffusing qualities of mineral oils. To manufacture the valve-oleum oils, lard oil, cottonseed oil, neatsfoot oil or lard-grease, or even fish oils, can be used to make the "Valve-Oleum" Gelatine, the mineral castor and the so-called honeydrop engine oils.

Neatsfoot oil is used to make the finest grades of "Valve-Oleum" cylinder oil, and for heavier and coarser grade cake-tallow can be used. Extra strained white lard oil or extra prime lard-grease is used to make the so-called "Valve-Oleum" white castor oil and the oil known as "Commercial Castor Oil," a cheaper substitute for the more costly castor bean oil. The oleate, margarate or palmitate, or stearate of alumina, is the combination preferably used in the manufacture of the "Valve-Oleum" Oils, although oleate of lime and oleate of lead can be used in like manner, the latter especially in the manufacture of paints, paint oils and factitious linseed oils.

Oleate of alumina is made in the following manner:

A solution of caustic soda is first prepared by dissolving caustic soda (some 160 pounds for a batch of 1,200 pounds of oil or fat) in about 90 gallons of water, thus making about 110 gallons of a caustic soda lye of from 22° to 23° Baumé. If the lye is freshly made, it will be heated by the chemical action which takes place between the dry soda and the water. In that case, if fat or tallow is to be used, it is only melted with heat so that the combined temperature of the fat with that of the hot lye will not exceed 250° F. If the lye has been previously prepared and has become cold, the temperature of the oil or fat should be increased to about 200° F.

TABLE OF PROPORTIONS OF CAUSTIC SODA TO GREASE OR OILS FOR OLEATE OF SODA IN THE MANUFACTURE OF THE VALVE-OLEUM LUBRICATING OILS.

Pounds of fat or oil	*Require of Caustic Soda*	*Dissolved in Water*	*Produces of Lye*	*Of specific gravity*
8 (1 gl.)	17 ounces	4¼ pints	5¼ pints	23° Bé.
40 pounds	5⅛ pounds	8 gallons	3½ gallons	"
50 "	6½ "	3⅜ "	4⅛ "	"
100 "	13½ "	7½ "	9⅛ "	"
150 "	20¼ "	11¼ "	13⅜ "	"
200 "	26⅞ "	15 "	18¼ "	"
250 "	33¼ "	18¾ "	22⅞ "	"
300 "	39½ "	20½ "	27⅜ "	"
350 "	46¼ "	26¼ "	32 "	"
400 "				
(50 gls.)	53 "	30 "	36⅝ "	"
450 "	59½ "	33¾ "	41⅛ "	"
500 "	66 "	57½ "	45¼ "	"
550 "	72½ "	42½ "	50¼ "	"
600 "	79 "	45 "	54⅞ "	"
650 "	85½ "	48¾ "	59⅜ "	"
700 "	92 "	52½ "	64 "	"
750 "	98½ "	56¼ "	68 "	"
800 "	105 "	60 "	73½ "	"
850 "	112½ "	63¾ "	77⅝ "	"
900 "	118⅛ "	67½ "	82¼ "	"
950 "	125 "	74¼ "	86⅞ "	"
1000 "	131½ "	75 "	91½ "	"
1200 "				
(150 gls.)	160 "	90 "	110 "	"

While constantly stirring, the lye is slowly run into the oil or fat and the stirring continued until the mixture has become a soapy, mushy compound and has assumed a perfectly neutral and soapy taste to the tongue. This will be accom-

plished in from one to two hours, depending much on the quality of the fat or oil, being fresh or old. The resulting product is the oleate of soda, which is next dissolved with boiling water. Previously from 550 to 600 pounds of alum (sulphate of alumina) are dissolved in about 6 barrels of boiling water, and when all is dissolved and the solution is perfectly clear, it is, while constantly stirring, gradually run into the solution of oleate of soda, enough of it until the oleate of alumina thus formed floats as a pasty compound on a clear, watery solution of sulphate of soda, the sulphuric acid of the sulphate of alumina having united with the soda of the oleate of soda, while the oleic acid of the oleate of soda has united with the alumina and formed "oleate of alumina." The whole mass is now started boiling and if any lathery foam still appears on the surface, some more alum solution is added, until all the foam has disappeared and the liquor remains perfectly clear. Next one barrel of 25° paraffine oil is added, and the whole briskly boiled and stirred for about one hour. Then the steam is turned off and stirring is stopped and the pasty mass allowed to subside over the clear watery liquid. This is then drawn off and replaced with fresh boiling water, and the boiling and stirring are resumed and several times repeated, until all taste of alum or sulphate of soda has been re-

moved. The last wash-water is then drawn off, and heating and slow stirring continued for a short time, and then discontinued, to allow of some more water, freely separating, to be drawn off from underneath the pasty mass. Heating and stirring are now again resumed, keeping the heat at a high and uniform temperature, until the pasty mass becomes turned from its white to a brownish color and has become perfectly clear and transparent and is pulling heavily, like molasses candy.

When a small sample of the mass, thrown onto a glass plate, shows perfectly clear and transparent and free from all moisture, paraffine oil, which has been previously heated to about 140° to 150° F. and kept at that temperature until all hygroscopic moisture and adhering light hydrocarbon vapors have been expelled, is then added by slowly running it into the batch while constantly stirring and keeping the temperature at from 150° to 160° F. for from two to three hours or more.

To make the "Valve-Oleum Gelatine" not too heavy and so as to allow it to be drawn off into barrels, but still warm enough to prevent it from chilling, from 3½ to 4 barrels of the paraffine oil to every barrel of fat or oil used in the making of the aluminate, are required.

To make a heavy and stringy mineral castor

for use on heavy bearings and machinery, some 40 to 45 barrels of paraffine oil to a 1,200-pound (or 3 barrels) batch of fat or fatty oil, are required, and more if a lighter grade is desired.

"Valve-Oleum" engine, so-called "Honey-drop" oil, is made in precisely the same manner, but in order to cut the stringy nature of the heavy castor oil to a honey-drop one, better adapted for oiling engines and lighter machinery, from 30 to 40 gallons of degras to a 1,200-pound batch are added together with the barrel of paraffine oil when boiling the compound, after the precipitation with alum and before the repeated washings.

For "Valve-Oleum" cylinder oil, a barrel of cylinder stock and from 40 to 50 gallons of degras are used at the boiling with the compound, if the cylinder stock to be used is of a reasonable cold test, otherwise a barrel of 25° paraffine oil is used. The batch is then finished up with from 40 to 45 barrels of filtered cylinder stock, which has also to be previously heated until all hygroscopic moisture and arising scum have been removed, as otherwise the combination will not remain uniform. Imitations of the "Valve-Oleum" oils for the sole purpose of giving to light distillates or poor paraffine oils some lubricating qualities, such as the so-called "Eldorado" oil and others, will easily thin out, separate and

lose their consistency, as they are only crudely mixed with distillates or light paraffine oils not previously freed from their adhering hygroscopic moisture and light hydrocarbon vapors in suspension.

White "Valve-Oleum" castor oil is made precisely like the "Valve-Oleum" engine oil, but extra white winter-strained lard oil or prime white lard grease is used in the making of the oleate alumina compound, and 300° white mineral oil in place of the paraffine oil.

"Valve-Oleum" castoroleum, also known as "Commercial Castor Oil," a cheap substitute for castorbean oil, is made by using white tallow or prime white lard grease for making the alumina compound, adding some 300° F. white mineral oil, to be boiled with the alumina bath, and, after washing and roasting the alumina compound down to a perfectly clear and transparent product, it is mixed with white summer cottonseed oil, previously blown at a low temperature, to a consistency of about 15° to 18° Baumé.

"Valve-Oleum" Linoleum is made by using linseed oil, fish oil, rapeseed oil or corn oil for making the alumina compound, boiling with an addition of neutral oil and mixing with linseed oil previously blown at a moderate heat to a consistency of about 18° Baumé. In place of alum, acetate of lead can be used to precipitate the

linoleate of soda, thereby forming a linoleate of lead.

The only notice accorded in recent years to the Valve-Oleum Oils is given in a German work on Petroleum Oils by Engler-Hoefer.* They are briefly mentioned as being oleates and palmitates of alumina and used to improve the viscosity of petroleum derivatives.

Origin of Valve-Oleum Oils.—From observations made by the author in the sixties, his attention was drawn to the fact that the fatty oils were then alone in use for lubricating machinery and that their lighter compounds, the oleic acid and the palmitic acid, were the real factors in the lubricating process, leaving the heavier stearic acid, unable to vaporize by frictional heat, to accumulate as gummy deposits on the bearings and cylinder. He also noticed that the oils produced by distillation of the petroleum oils were exclusively operated on to obtain the more valuable crystalline wax they contain, and the remaining paraffine oil was used for lubricating, and he also observed that depriving the paraffine oils of their wax, they were also being deprived of their viscosity or adhesiveness, the property that holds the otherwise too fluid oil to the metals and allows its lighter constituents to do their work and evaporate with the absorbed frictional heat into space.

* "Das Erdoel," Leipzig, 1913.

To remedy this defect the paraffine oils were then compounded with additions of fatty oils, but it was soon found that the free fatty acids of which all fatty oils are composed acted injuriously on the metal of which machinery in constructed. The idea was then conceived to bind the fatty acids to neutral metallic bases, thereby making them innocuous and permitting their excellent clinging power as viscosity to be combined with the great diffusing power of the mineral oil, thus creating Valve-Oleum oils.

The following receipt from a German report is similar to Valve-Oleum Oils.

Aluminium-lanolate Lubricant.—Precipitate an emulsion of wool-fat in soda lye with concentrated alum solution. The precipitate forms a brown, soft, spongy, sticky mass (aluminium lanolate) and is freed from salt and soap by pressing and washing with hot water. It is then dissolved in mineral oil. With 14 parts of mineral oil of 0.885 to 0.886 specific gravity 1 part of aluminium lanolate yields a lubricant of the viscosity of olive oil.

X.

LEATHER OILS.

LEATHER belts, harness, boot and shoe leather require as much attention in regard to lubrication as does machinery. Hides, when deprived of their natural lubricating moisture, become dry and easily break. When converted into leather for belts, harness, boots and shoes, it would soon become useless for wear were it not for the interposition of the fatty lubricants known as "leather stuffings," which relieve the frictional action of fiber against fiber of which leather is composed. The more volatile these fatty lubricants are, the oftener they require renewal, lest the frictional heat and the abrasion of the fibers against each other, heat, burn and destroy the leather. We therefore try to protect the leather and make it more durable by the different finishing processes to which it is subjected, but unless the frictional action of fiber against fiber is relieved by constant lubrication, the frictional heat will destroy the fiber. For this purpose leather oils for lubricating, water-proofing, softening and preserving leather are generally compounded after one or the other of the following formulæ;

Valve-Oleum Leather Preserving and Water-Proofing Oils.—Two barrels of "Valve-Oleum" gelatine made from neatsfoot oil, as described on page 71 et seq., are compounded and well mixed with two barrels of coon oil, neatsfoot oil or fish oil (tanners' oil). Thereto are added five pounds of Para-gum, cut into fine shreds and dissolved by heat in five gallons of coon oil or neatsfoot oil. It can be colored with a sufficient amount of black West Virginia or Mecca oil, or with fine lamp-black ground in fatty oil. The fatty oils used should previously be heated until all their hygroscopic moisture is driven out, and the arising scum skimmed off, before mixing with the gelatine.

An oil for tanners' use is made also with "Valve-Oleum" gelatine and fish oil (train oil) with additions of paraffine oil of low specific gravity.

A cheap harness oil is made with one barrel of "Valve-Oleum" gelatine and eight to ten barrels of heavy black petroleum oil and colored with gilsonite (Egyptian asphalt), gum or lampblack ground in neatsfoot or fish oil.

A black harness oil is also made with fifty barrels of dip oil, fifteen barrels of spindle or red oil, five barrels of degras and two barrels of lamp-black ground in neatsfoot oil or fish oil.

A good belt oil can be made by dissolving by heat 150 pounds of rosin in one barrel of castor-

bean oil and scenting it with citronella or myrbane oil. Paraffine oil, in which four to five pounds of rosin to the gallon have been dissolved, can be substituted for part of the castor-bean oil.

For belt oil Para-gum also is dissolved in neats-foot oil and compounded with "Valve-Oleum" heavy castor oil.

A belt grease is made by dissolving in fifteen parts of fish oil and five parts of tallow, with heating and stirring, five parts of India rubber (Para-gum), cut into fine shreds, and adding four parts of rosin and four parts of beeswax; stir well until congealed to proper consistency.

Fluid Adhesion-Fat for Belts, is made according to a German process as follows: Bring into an iron kettle, saponified olein about 60 per cent, vaseline oil about 15 per cent., castor oil about 5 per cent., rosin about 20 per cent., and, whilst stirring constantly, heat sufficiently for the rosin to melt and to effect an intimate mixture of the ingredients. The mixture is then boiled for about 7 to 8 minutes. It should be borne in mind that the mixture has to be constantly stirred from the beginning to the end of the operation. The use of saponified olein results in the product being obtained, after the boiling process, clear and free from any segregation. If, in place of saponified olein, tallow-olein is used, the mixture thickens and does not remain clear and fluid. If

less olein and more vaseline oil were used, segregation would soon take place; the olein (oleic acid) would float on the top and the other constituents form a sediment. With the use of saponified olein and the other ingredients mentioned an adhesion-fat is obtained that always remains fluid and does no thicken. The fat is applied by means of a brush to the underside of the belt, if possible while not running, to give the fat time to thoroughly penetrate, care being had to use only as much as the leather can absorb. The upper side of the belt need only be greased when it runs in water and is exposed to wet, vapors and chemical influences, or drippings from machinery, but it should in that case be first thoroughly freed from adhering grease, dirt, etc.

Factitious Paint Oil.—A cheap substitute for linseed oil is made by dissolving rosin oil in neutral oil and mixing it with linseed oil—2¼ gallons of linseed oil, 2½ gallons of neutral oil, with from 2½ to 3 pounds of rosin—the whole being improved by boiling with oxidizing agents, or acetate of lead until all the acetic acid of the latter has been expelled and the oil has become bright and clear.

A cheap paint oil is also produced by compounding blown linseed oil with neutral oil and a sufficient amount of dryer made from rosin spirits.

XI.

ADULTERATIONS OF FATTY OILS.

WHEN the market price of lard oil is high and that of cottonseed oil is low, the former is often adulterated with the latter. It is also adulterated with petroleum oils, especially prepared for that purpose, and with addition of refined and deodorized rosin oil, to equalize the specific gravity of the mixture to that of pure lard oil. No. 1 lard oil is adulterated with white neutral oil and No. 2 lard oil is adulterated with yellow neutral oil.

Olive oil is also much adulterated with cottonseed oil, sunflower oil and others, when their market prices, being lower than that of olive oil, warrant such adulteration.

Sperm oil is much adulterated with cheaper fish oils, well refined, deodorized and bleached.

Linseed oil is adulterated with corn oil, cottonseed oil, rapeseed oil, hempseed oil and rosin oil.

Sperm oil should not contain less than four per cent of cetin unless adulterated. Shake one part by weight of sulphuric acid of 1.84 specific gravity, with four parts of the oil; allow to stand for

about twenty minutes, shaking twice; add three ounces of distilled water, shake well and allow to stand sixteen to twenty hours; dilute then with three or four times its volume of distilled water and mix thoroughly. On standing the cetin floats on top and can readily be skimmed off; then wash, dry and weigh. It is soluble in chloroform.

Castor oil is adulterated with blown oils, such as linseed, rape or cottonseed and rosin oils. If only ten per cent of them be present, they cause a turbidity with absolute alcohol, with which castor oil is miscible in every proportion.

XII.

TESTING OILS.

ALKALI tests are made to ascertain first if an oil is a pure fatty oil, or a hydrocarbon oil, or a mixture of both. A solution of caustic soda or potash of a specific gravity of 1.340 is prepared and two volumes of this solution are shaken up with four volumes of the oil to be tested. After standing, the oil separates out, leaving an aqueous layer clear or slightly clouded. If hydrocarbon oils are in large proportion in the sample, they will form a layer on the top and the aqueous layer will be emulsified. If the fatty oil is in largest proportion, the smaller proportion of hydrocarbon oil will be more difficult to detect. To ascertain this, dissolve a piece of caustic potash the size of a pea, in 5 c.c. of alcohol. Then add a few drops of the oil to be tested and boil for two to three minutes and add from 3 to 4 c.c. of distilled water. If the solution remains clear, only fatty oil is present. Mineral oil will cause the solution to be turbid and even as small a quantity as 2 per cent. present will show itself this way.

The amount of mineral oil in fatty oils is also ascertained by mixing 25 grammes of the oil with 10 to 15 c.c. of the caustic potash solution and 25 c.c. of water and 5 c.c. of alcohol. This is boiled, constantly stirring, for about one hour. By that time the fatty oil is saponified. Put the whole in a separating funnel and add more warm water and 25 c.c. petroleum ether; shake for a few minutes and allow to stand. The upper stratum is composed of the petroleum ether and the mineral oil and the lower stratum of the aqueous layer of soap formed by the fatty matter. This is run off, clean water is added, stirred together, and the whole again allowed to stand and the aqueous liquor run off. This is repeated until the latter runs off perfectly clear. Now put the ethereal layer into a weighed vessel, evaporate the ether and weigh the remaining oil; the weight multiplied by four gives the percentage of mineral oil in the sample.

A color test can be made by placing some 20 drops of the oil in a porcelain cup and adding two drops of strong sulphuric acid. As the acid drops through the oil, streaks of color are shown, and a tint of characteristic color gradually spreads through the oil. Then stir the whole and again note the coloring. Vegetable oils give various colors, shades of yellow-brown or green; fish oils turn to violet or purple, animal oils to a reddish-

brown, and hydrocarbon oils turn slightly to a blackish-brown. The test should first be made with samples of known pure quality and compared with the action of the sample under test.

Agitating 4 c.c. of the oil to be tested with 10 c.c. colorless nitric acid will show, after settling, when olive oil has been adulterated with cottonseed oil, by a brownish color, while pure olive oil will not become darkened.

For a test of cottonseed oil in lard oil put ½ ounce of nitro-sulphuric acid and ½ ounce of the oil to be tested in a glass vessel and stir well. Pure lard oil becomes hard in two to three hours, but when adulterated with cottonseed oil the sample may thicken but will not become hard.

For a preliminary test for neutral oil in lard oil, shake the suspected sample violently in a bottle. If it contains neutral oil it will form beads or bubbles that will pass away when the oil is pure, but if adulterated with much neutral oil it will have a tendency to foam.

To detect small quantities of fatty oils, of ½ to 2 per cent. in a sample of mineral oil, some of the oil is heated for about fifteen minutes, with bits of sodium or sodium hydrate, to about 230° to 250° F. Fatty acid present will solidify to a jelly of more or less consistency, according to the amount of fatty oil therein.

To detect soap dissolved in mineral oil, five to

ten per cent. of the oil is dissolved in about fifteen parts of gasoline or ether, and solution of phosphoric acid added. The formation of flocculent precipitate indicates the presence of soap.

To detect acidity or alkali in mineral oil, shake a sample of the oil with an equal quantity of warm water, pour off the oil when settled, and test the water with litmus paper. Acidity will turn blue litmus paper red, and if alkaline, will turn red litmus paper blue, and yellow turmeric paper brown.

We will not enter any further into the inexhaustible field of chemical and technological testing of oils, but would call attention to some simple and practical methods for testing oils and oil mixtures, as to their purity and efficiency as lubricants, that can be carried out by the most inexperienced investigator.

First are to be secured samples of known purity of the different kinds of animal and vegetable oils used in the manufacture of lubricants, and then proceed with the testing of the oils to be investigated as follows:

All fatty oils of animal or vegetable origin possess an odor and taste peculiar to themselves, which becomes more distinctly noticeable when the temperature of the oil is increased. If, therefore a few drops of the oil, to be investigated as to its characteristics or origin, are placed in the

palm of one hand and vigorously rubbed by the other until a burning sensation is experienced, we can ascertain the individuality of the oil by the smell from the flavor known to be peculiar to it and corresponding with that of one of the samples of known origin and purity. We can thereby tell if it is lard oil, cottonseed oil, tallow oil, fish oil, palm oil or rosin oil, etc., and by this method we can in many cases also ascertain which of these oils may be intermixed with another. When the oils are fresh and pure and carefully purified and bleached, their peculiar odor is not so readily noticed as when they are older; but by slightly heating between the hands we are enabled to recognize their characteristic odor.

Tasting oils will also enable us to ascertain their individuality, when we make comparison of their taste with that of the samples of oils, the purity and character of which is known to us.

The intermixing of fatty oils for purposes of adulteration, when the one oil can be bought in the market at lower price than the other, is not very detrimental in their use for manufacturing purposes, but when fatty oils have been adulterated with petroleum oils, the difference in value and the thereby lowered quality of the oil, demands investigation. Lard oil, cottonseed oil, neatsfoot oil and other fatty oils, are more or less adulterated with high-fire-test petroleum oils,

and with such of them as have been especially prepared and deodorized for that purpose. Such adulterations can be detected by the following simple tests:

When petroleum oil has been admixed in large proportion, the simple pouring of some of the oil on a dark ground, or, onto a smoked-glass plate, in a place where the sunlight can fall on it, will give sufficient proof of the presence of petroleum oil, by its bluish, fluorescent lustre. Its presence can also be ascertained by the use of the hydrometer. As the specific gravity of petroleum is so much higher than that of fatty oils, the hydrometer cannot fail to indicate by the so much increased specific gravity of the mixture above the well-known lower gravity of pure fatty oils, that petroleum is present and how much of it. Its presence in fatty oil compounds can further be ascertained by slowly heating a sample of the suspected oil in a porcelain dish over a spirit lamp, with a thermometer suspended in it, and by applying from time to time a lighted match to it and note the temperature at which the oil will ignite. Petroleum used for compounding with fatty oils will vaporize and ignite at from 110° to 300° F. while fatty oils require for ignition twice as much heat.

To ascertain with what proportion of petroleum a fatty oil has been adulterated, samples are pre-

pared and mixed in various definite proportions. Mark on each sample the proportion of petroleum added to the oil, the specific gravity ascertained by the hydrometer, and the temperature at which it became ignited. By submitting a sample of the oil to be investigated to the same test, we can easily ascertain the proportion of petroleum it contains, by comparing the result of the test with those marked on the prepared samples.

We can tell of the presence of petroleum in fatty oils, even in very small proportions, by placing a small quantity of the suspected oil on our tongue and subjecting it to the motion of mastication, the same as if we were tasting some other fatty nutriment, such as butter or lard. The alkaline saliva in the mouth will act upon and unite with the fatty oil of the sample but not with the petroleum oil it contains, and after the fatty oil has become absorbed by the system, the presence of petroleum will manifest itself by its remaining nauseating taste.

To prevent detection of adulteration of fatty oils by the hydrometer test, fatty oils are often mixed with petroleum and refined rosin oil, to equalize by the low specific gravity of the latter the lighter specific gravity of the petroleum. Their presence, however, is easily detected by taste and likewise by smell, when heated by friction between the hands, as before explained.

The comparative efficiency of oils for lubricating can be tested in many ways without the use of costly testing machines. To ascertain the gumming propensities of an oil we need only to spread some of it in a very thin layer over a glass plate, protect it against dust, and expose it to the sunlight or other slow, dry heat. In a short time the gumming propensity of the oil will be indicated by the tough and sticky appearance of what of the sample remains on the glass.

Viscosity.—Viscosity is the degree of fluidity of an oil. The greater viscosity or body one oil possesses over another can be ascertained by allowing a given amount of the oils to be tested to drop out of the narrow end of a glass tube, or count the drops falling from them in one or more minutes and compare the difference. By varying the test at a colder or warmer temperature, the uniform consistency of the oils can likewise be ascertained and compared.

By pouring a drop of oil to be examined on a well-cleaned glass plate placed on an incline, alongside of another placed likewise, aud noting the time it takes for each oil to reach a mark made on the bottom of the inclined plane, we can observe to some extent the greater viscosity or body and clinging power one oil possesses over the other. By increasing the temperature by means of an alcohol lamp or otherwise, we can

likewise judge of the relative consistency one oil maintains toward another, or compare it with like tests made with oils of known efficiency.

Cold Test.—For the cold test of petroleum and lubricating oils, the principal process usually followed by the oil trade without the use of the many expensive apparatuses in the market for that purpose is as follows: The oil is brought into 4-oz. glass bottles such as used for oil samples, and placed in an empty tomato can or other suitable vessel. A thermometer is placed in the oil through the mouth of the bottle and crushed ice or snow with common salt (chloride of sodium) in alternate layers is packed around the bottle up to the neck. The thermometer is examined from time to time as to the temperature at which the freezing proceeds and the degree noted at which the oil solidifies.

Fire Test.—The oil to be tested is placed in a porcelain dish over an alcohol or oil lamp. A thermometer is suspended in the oil to a short distance from the bottom. The lamp is lit and allowed to slowly heat the oil. A lighted match is from time to time passed over the surface of the oil and the degree on the thermometer noted when a flashing from the oil takes place. The heating is continued until the lighted match sets the surface of the oil on fire. The degree indicated on the thermometer when this takes place indicates the fire test.

The test often made with cylinder oil, by pouring some of it onto a cylinder chest, cannot be considered conclusive, as the temperature on the outside of a cylinder chest is dry and scorching, while the temperature inside the cylinder, where the oil is expected to perform its work, is moist. That an oil would show less tendency to evaporate in the dry and scorching heat on top of the cylinder chest, would only indicate its higher fire test, but high fire test is no criterion as to its qualities, as the temperature inside of the cylinder can never be a dry and scorching one. The fire test of an oil should always be in proper proportion to its heat-absorbing quality, or it will suffer decomposition and produce gummy deposits by its inability to vaporize fast enough under the frictional heat and carry its vapors diffused with the exhaust steam into space.

Simple Way of Testing Lubricating Oils.—A very handy and simple way of testing oils is to place them side by side on white blotting paper and place this for a short time on a cylinder chest or a steam heater. The oil which penetrates the blotting paper quickest and spreads widest over it, is always the poorest and thinnest oil, as it shows by its lightness and the quick disappearance of its outer ring, that it is compounded from material of very light specific gravity. If by giving it some time, or by longer exposure to

heat, the whole of the oil on the blotting paper disappears, the sample must be composed entirely of petroleum, and when an inner ring, with a well discernible line, is formed and remains longer, a proportion of paraffine-holding stock must have been compounded with lighter petroleum, and when a center ring, with decided outline and darker color, is formed, but no permanent translucency is imparted to the paper, the compound must be made of a light hydrocarbon oil, with an addition of still-residuum stock, however, well refined or bleached. If the oil to be examined has been compounded from petroleum, with an addition of lard oil or tallow oil or other fatty matter, the blotting paper will retain its translucency in the center long after the petroleum, which at first spread rapidly over and through the paper, has disappeared. Petroleum penetrates blotting paper faster than fatty oils and spreads wider over it at first, but dries off rapidly and its translucency disappears; while that of fatty oils remains, as one of the principal characteristics of fatty oils is their faculty to render paper permanently translucent.

Practical Tests of Lubricating Oils.—Tests made by the practical use of the oil are by far the best, but we must not allow ourselves to be deceived and be led to attribute too rashly any unsatisfactory results at first obtained, to the oil we are

testing. If the oil previously used was an impure one and of a gumming quality, however satisfactory it may have appeared to work, it will have left its gummy deposits in crevices and joints and in the interstices in the metal, which is commonly regarded as a bearing which the oil has made for itself, and when the new oil to be tested is applied in too small a quantity, we fail to observe that such a small amount of purer oil has at first to contend with and dislodge the deposits, which may be the result of long standing and the accumulations of large quantities of the oil formerly used. It is this fact that misleads and often causes the better oil to be condemned, until a larger and longer application proves the correctness of this statement.

These same facts will appear when we apply for a test a poorer and impure oil, after having used an oil of purer and better quality. The poorer oil finding all the bearings or the cylinder clean and no gummy deposits to contend with will, for a time, appear to work equally as well as the good oil that was in use before.

Cylinders and bearings, as well as the feeding cups, should be carefully cleaned before testing or using a new oil, if we wish to be able to judge correctly as to its quality.

Objection is sometimes made by engineers to the stringy character of the "Valve-Oleum" oils,

but this stringy nature, while perhaps somewhat inconvenient under careless handling, constitutes the very life of the oils, secures their uniform consistency in cold as well as in warm weather, and enables them to cling tenaciously to the metal, absorb the frictional heat as fast as it is generated by the motion, and permits their body to be of light enough character to vaporize rapidly into space with the heat they have absorbed.

Unscrupulous parties, making imitations of the "Valve-Oleum" oils, use their stringy characteristics solely for the purpose of artificially thickening light and otherwise unsalable petroleum oils, but such mixtures do not stay together; they separate and are not neutral and contain free fatty acids, and are but little more efficient for lubricating than the cheap petroleum distillates.

By the blotter test, the "Valve-Oleum" oils show their fatty characteristics by leaving permanent, translucent center spots on the paper; they show their uniform consistency by being slowly absorbed by the paper and spreading over it without separating, and they show their cleanliness by leaving no deposit of impurities on the paper.

To detect one part of oleate of alumina in 10 parts of mineral oil, heat the sample with distilled hydrochloric acid over a water bath and stir well. The hydrochloric acid absorbs the alumina and

the fatty acid remains in the mineral oil. The mineral oil is drawn off and treated with soda lye which combines with the fatty acid and separates from the mineral oil.

XIII.

SOLID LUBRICANTS. GREASES.

SOLID lubricants consist principally of filtered stock or vaseline, and they are fed to the bearings through cups especially devised for that purpose, and furnished with screw pressure, or provided with copper rods, which latter, touching the shaft, cause feeding of the vaseline or other greases by communicating the frictional heat to them, whereby they are liquified, and caused to flow onto the shaft and into the bearing.

Greases for lubricating consist principally of tallow or lard, of either or both, together with palm oil, rapeseed oil, degras, rosin oil and petroleum oils brought to a proper consistency by semi-saponification with weak lye, limewater, or lime-soap, or lime-paste.

Fatty matter of all kinds and quality, residuum and tar from refineries, in short all that cau be worked into this kind of lubricant, and can be given a greasy appearance and consistency, is worked into what is known and sold in the market under the name of "Lubricating Grease" Cup Grease, Axle Grease, etc.

The character of the machinery for which this kind of lubricant is used is of the coarser, heavier kind; hence less attention is generally given to ascertain the indirect advantage that would result from the use of grease of best quality, cost being generally the only point considered.

Here also, as with the lubricating oils, it is the fatty acid alone which is the lubricating, that is, the heat-absorbing and eradiating principle, held to the moving surfaces by medium of the stearin, palmitin, rosin or, paraffin, the latter being ultimately left as concentrated and charred gummy deposits.

With grease lubricants the wear and abrasion of the metal is always greater than with oil lubrication, as the consistency of the grease requires greater accumulation of frictional heat to melt and convert it into a liquid state before it is enabled to reach the place where it is expected to do its work.

Carefully conducted experiments have demonstrated the fact that it takes some twenty-five per cent less power to move machinery lubricated with oil than when lubricated with grease, and at a some thirty to thirty-five per cent lower temperature.

The additions of lime, graphite (plumbago), lead, asbestos fibre, mica, sulphur, soapstone (talc) and all other inert matter, to grease, used on

machinery moving under great pressure and heat, act only as a medium, filling the interstices in the metal, and serve only as a sort of cushion for the real lubricant, the fatty matter contained in the grease. These inert substances cannot vaporize with the frictional heat and must, therefore, remain as gummy accumulations and metallic abrasions on the bearings.

Manufacture of Greases.

Most greases for lubricating are made in the following manner: Common red rosin oil, say five hundred pounds, is heated for about one hour with about two pounds of calcium hydrate. It is then allowed to cool and is skimmed, and from ten to fifteen pounds of rosin oil-lime soap are slowly stirred in until the mixture assumes a buttery consistency. Lime soap is made by slowly heating and mixing 100 pounds of crude rosin oil with some 80 pounds of hydrate of lime, and boiling into a molasses-like consistency.

For rosin grease, lime paste is made by slaking say 10 pounds of quicklime with about 40 pounds of water; the whole is then passed through a sieve to separate all coarse particles, and to allow the fine lime-paste to settle. The water is then poured off and from 6 to 8 gallons of crude rosin oil are stirred into the lime-paste and allowed to stand for a few hours. All accu-

mulated water is then drawn off and from 8 to 10 gallons of mineral or heavy petroleum oil are added. The whole is then heated to about 230° to 240° F., stirred and well mixed and allowed to cool and set to proper consistency.

A rosin grease, without heating, in the cold way, is made by mixing and stirring well together 20 gallons of crude paraffine or other mineral oil, in which some 80 pounds of rosin have previously been dissolved by heat, with a lime-paste made by slaking one-half to three-quarters of a bushel of lime, sifting it from all coarse particles and separating most of the water from it. It is stirred until a smooth, uniform consistency is obtained. From 3 to 5 gallons of crude rosin oil are then slowly added and stirred to a proper buttery consistency. The product of this process is the well known "Valve-Oleum Zola Axle Grease". Additions of fats or fatty oils improve its quality.

The following are some formulas after which nearly all grease lubricants are manufactured:

Half a pound of caustic soda is dissolved in one gallon of water; from three to five pounds of tallow and one-half to one gallon rosin oil are added, and the whole is heated to about 210° F. and well mixed, and then stirred, as it cools, to its proper consistency.

Forty gallons petroleum oil, fifty pounds of

yellow grease or tallow and sixty pounds of rosin are heated together at a temperature of about 240° F. From two to two-and-a-half gallons of soda lye are then gradually added, and all is mixed and stirred well. When cold, in about twelve hours, it will be ready for use.

For a *cup grease*, seventy-five pounds of tallow, thirty to fifty pounds of rosin, some thirty to forty gallons of paraffine oil, and about ten to fifteen pounds of oleate of soda or common soap are melted together and stirred until a uniform and smooth buttery consistency is obtained.

Also : One part of tallow or yellow grease, four parts of cylinder stock or paraffine oil of a low gravity, and one-quarter part of caustic lye of from fifteen to twenty degrees Baumé, are heated and stirred until cold and of proper consistency.

Dark Axle Grease: Thirty-five gallons West Virginia black oil, in which some fifty pounds of rosin have been dissolved by heat, and lime-paste from half a bushel of lime, are well stirred and brought to a proper consistency by the slow addition of from four to six gallons of crude rosin oil.

Linseed Oil Grease: One hundred pounds of tallow, one hundred pounds of rosin and ten to twelve gallons of linseed oil, with from six to eight gallons of caustic soda-lye of about five degrees Baumé, are boiled together and allowed to cool and set to proper consistency.

One gallon petroleum oil, one-half pound tallow, one-half pound palm butter, one-half pound plumbago and one-quarter of a pound of soda are heated and kept for about an hour at a temperature of about 180° F., then allowed to cool down, and are stirred until well setting to consistency.

Or: Water, one gallon, one-half pound soda, three to five pounds of tallow, from six to ten pounds of palm oil and sufficient rosin to give the desired consistency, are heated to about 250° F., well stirred until cooled down to about 70° F., and allowed to set.

Or: Ten pounds of common soap well dried and cut in small pieces, from fifteen to twenty pounds of filtered cylinder stock and about fifteen pounds of heavy petroleum oil, are heated to about 230° to 240° F., and well stirred until all the soap is dissolved, and the whole is then allowed to cool to proper consistency.

Or: Palm oil, tallow, or tallow oil and soda, dissolved in as little water as possible, are heated and stirred into a uniform buttery mass.

Or: One gallon crude rosin oil, two to three pounds of quicklime slaked with about one gallon of water are mixed and allowed to settle and the adhering water drawn off. Heavy petroleum oil and from three to five pounds of graphite (plumbago) are then added, and all well mixed

and stirred to a uniform and buttery consistency.

One per cent of castor oil soap will solidify paraffine oils in vacuum to a solid grease.

The manufacture of all greases is based on a semi-saponification of fatty matter. Below are given a number of formulas for the manufacture of grease as practised in Germany in latter years.

Palm Oil Grease.—I. Melt together, tallow 150 parts, palm oil 100, soda 25, water 160.

II. Tallow 100 parts, palm oil 160, soda 35, water 300.

III. Rosin 100 lbs., palm oil 6½ lbs., refined rosin oil 18½ lbs., soda lye of 22° Bé. 24½ lbs., water 2 lbs. Melt the rosin in an iron kettle over a moderate fire and saponify it by adding the caustic soda lye and the water. The melted palm oil together with the rosin oil is then brought into the kettle and by crutching combined with the saponified rosin. Stirring is then continued till the mass is of uniform consistency.

Yellow Axle Grease.—American rosin 100 lbs., caustic soda lye of 20° Bé. 12½ lbs., crude rosin oil 12½ lbs. Melt the rosin in an iron kettle, then add gradually the soda lye, and finally, whilst stirring vigorously, the rosin oil.

Axle Grease prepared in the cold way.—The process of the production of this grease is based upon the property of rosin oil to saponify with ease when mixed with slaked lime in the form of

powder. The lime used must be fat and contain up from 96 to 98 per cent. calcium hydrate. A content of 5 to 8 per cent. of magnesia in the lime is a drawback to saponification, small dull globules of fat being segregated. Saponification is most readily effected at 64° to 68° F.

I. Blue mineral oil 70 per cent., slaked lime 10 per cent., rosin oil 15 per cent.

II. Blue mineral oil 60 per cent., slaked lime 9 per cent., gypsum 18 per cent., rosin oil 13 per cent.

III. Blue mineral oil 36 per cent., naptha residue 36 per cent., slaked lime 11.5 per cent. rosin oil 15.5 per cent.

IV. Blue mineral oil 20 per cent., gypsum 40 per cent., rosin oil 8.5 per cent., lime 8.5 per cent.

Bring the mineral oil and the very dry slaked lime into a vat and after mixing for half an hour pass the mixture through a hair-sieve (25 to 30 meshes to the square centimeter) into another vessel, pressing through any particles of lime. Then add the naphtha and other ingredients and stir thoroughly. Finally add the rosin oil and knead the whole to a butyraceous mass.

XIV.

SOME PRACTICAL SUGGESTIONS.

WHEN a cylinder becomes partly worn, or ridges and scars are cut on its bright surfaces, or a partial wearing of the piston rod takes place, it is absurd to lay such results to the oil. Oil cannot cut metal, the cause of such injuries being a purely mechanical one; some parts are loose or out of line or otherwise defective in construction, and no amount of oil or fat of whatever quality is capable of preventing gradual increase of the injury and final necessity for extensive repairs.

No kind of oil or fat can cut ridges or scars in metal. It requires metal or inert substances, such as silica, lime, emery or mica to do it. They do it suddenly and violently when dry and by themselves, and they do it slowly and silently when intermixed and saturated with oil or fat. The idea that mixing silex, sulphur or plumbago (graphite), etc., with oils or fats, to give them increased lubricating power, is erroneous. These inert matters have nothing whatever to

do with the lubricating, which is alone done by the oily part of the compound, leaving the inert matter behind, to accumulate on the bearings, and with every new application, by and by will fairly choke the cylinder and the valve-chest.

All fatty oils and fats, without exception and of however excellent quality, either alone or compounded with mineral oil, when applied as lubricants, are decomposed by the steam and by the frictional heat they absorb, and their lighter constituents vaporize and leave the heavier ones to form gummy deposits with the fine metallic particles, the result of abrasion, and with the impurities in the water used.

Such deposits cause dragging of the machinery and waste of power, accumulate gradually in crevices and fill the smallest interstices in the surface of the metal; they settle all around the joints and are found in abundance behind the rings and piston.

The injurious action from the use of tallow in cylinders is well known. The action of the stearin on the metal increases the abrasion, and injury is wrought slowly but entirely uniformly, and by no means in cutting ridges and scars in the iron.

When tallow or very impure fatty oils have been used, or they have been further compounded with inert matter, such as plumbago, etc., the

accumulations are still more abundant and detached parts are frequently found worked into marble-like balls by the continuous churning motion of the piston; they dry against the heated metal and gradually assume the hardness of stone or iron.

Lubricating oils which are not so constituted as to decompose readily and form gummy deposits, are capable of softening and gradually dissolving such hardened deposits. Some particles partly dissolved become detached and get between the piston and the cylinder and commence cutting and scraping into the smooth sides of the latter. A groaning noise gives audible warning and, if the impediment is not removed or relieved by speedy softening and dissolving with more copious application of better oil, the injury inflicted may become very serious and may necessitate the stopping of all machinery and require expensive repairing.

There are also numerous instances on record where small particles of metal broke off from worn-out springs with too sharp and not properly rounded edges, or from careless keying of the valves, and finding their way between the sides of the cylinder and piston, cut heavy ridges in the iron. It is ridiculous to blame the oil for it.

Another source of injury in cylinders, other-

wise perfectly clean, arises often from the use of poor packing, overdone with sulphur or overheated in vulcanizing, which has become brittle from exposure and age, or being burnt from long contact with the heated metal. The ragged edges of such packing will become detached, contaminate the oil, and cause injury.

If a babbit or other metallic lining has been placed in a bearing in a bungling manner, or small particles of the metal have broken loose from a raggedly bored hole through which the oil is to be applied, and such particles find their way between the moving parts, cutting and scarring of the metal cannot be prevented with the best of lubricants.

If an employee forgets and fails to apply oil in proper time, and the parts run dry, get heated and cutting takes place, the trouble is generally attributed to the lubricant, but all this proves that it is impossible for an oil to "cut metal," but that impurities in oils, accidentally or intentionally combined with inert matter, will do it.

Acid in oil is often regarded as the cause when cutting of metal has taken place. That can be the cause when fatty oils are used for lubricating as they are liable to absorb oxygen from the atmosphere and, becoming rancid, develop their constituent fatty acids which act injuriously on metal. But acid cannot be in petroleum oils un-

less left there from faulty washing, or when having been compounded with crude fatty oils. By the process of the manufacture of the Valve-Oleum oils, these fatty acids fixed to a base have thereby been rendered innocuous.

The parts of machinery where oil is used for lubricating should be kept clean and carefully examined, to see if they are in proper condition; that no foreign matter has by chance got between the moving parts or is liable to do so; that keys on wristpins and bolts on bearings, hangers, etc., have not gradually been loosened by the constant jarring of the machinery; that flooring has not settled under heavy weight and thereby the shafting, attached to it, been put out of line or otherwise interfered with.

All these points are generally only thought of after some accident has happened or warning is given by a groaning or squeaking noise, and when some parts are found heated and cut, and the blame is unjustly laid to the oil, until investigation reveals the real cause.

XV.

LUBRICATORS AND CUPS.

THE many contrivances commonly called "lubricators," by which lubricants are applied to machinery, are often much trouble to engineers, as the adoption of these contrivances is, with many, as much a consideration of price only as it is in the purchasing of lubricants; but with lubricators as well as with lubricants the best are always the cheapest. It is a great oversight to make the lubricant subject to the manner of applying it, as it is the lubricant that is to do the work and not the mechanical contrivance through which it is forced to do it. There are numberless such contrivances, many very ingenious ones and others of faulty construction, rather interfering with, than assisting, the lubricant to do its work properly.

Cylinder oils are applied by the hand-pump, by the automatic pump, or through the well known sight-feed lubricators.

The hand-pump admits the oil too irregularly, too much at one time, not enough at another, either from neglect or oversight.

The automatic pump, such as the first and well-known "Moses Pump," and the later improved styles, are the best means for applying oils to cylinders with proper regularity. With the automatic pump the oil is not brought in contact with water or steam before entering the cylinder. It supplies the oil with the starting of the engine and ceases to do so when the engine is stopped, and all the attention that is required is to keep the pump supplied with oil. Any kind of oil, if clean and free from grit, can be fed through these pumps, and the amount to be fed is easily regulated by the shorter or longer stroke that is given at its connection with the engine.

The proper feeding of cylinder oil through the modern sight-feed cup, now generally used, depends entirely on the intelligence of the engineer as how to use it properly. All the many sight-feed cups are devised on the principle of displacing the oil from the cup, drop by drop, by the water condensed from the steam before the latter reaches the cup. It requires a little time and patience when starting or refilling these cups, to wait until sufficient steam has been condensed and enough water been accumulated to operate the cup properly and get the oil to feed with proper regularity; otherwise the steam will churn the oil. Introducing some water in the cup before filling with the oil, and slowly turning on

the steam and regulating the feeding, will prevent overheating and allow of regulating at once the proper condensing of the steam and the regular displacement of the oil.

The use of impure oils should be carefully avoided and the cleaning of the cup not attempted by blowing live steam through it, as thereby the fatty deposits from the oil, in connection with impurities in the water used for the steam, are baked to the sides and openings of the tubes in successive layers by the latent heat held there by the metal, in precisely the same manner as the scale in boilers is produced from the slimy, earthy deposits of the water, by baking and incrusting them on the iron by the latent heat under the prevalent and injudicious practice of "blowing off boilers." Sight-feed cups should be taken off from time to time and carefully cleaned with benzine or coal oil and a swapper.

It is, however, not a question alone of merely getting the oil into the cylinder, but the oil must possess sufficient power to cling to the metallic surfaces of the cylinder and the valves, in order to resist its being blown out with the exhaust before its work has been done.

An oil that does its work satisfactorily when applied direct with a pump, but will not do so through any of the many patent sight-feeding devices, proves conclusively that the lubricator

or the wrong handling of it should be blamed, not the oil.

There is an endless number of cups of all kinds of construction to apply lubricants to the bearings of shafting and all kinds of machinery. For feeding oils, those will command the most attention that will allow the operator to see at a glance if the feeding is regular and uninterrupted. They all require more or less adjusting to properly regulate the amount to be fed and allow the oils to pass through the aperture, according to their limpidity or viscosity.

In some of them the flow of oil is regulated by controlling the width of the aperture with opening and closing devices; in others a wick is placed over the aperture, to secure regular and slow feeding on capillary principle, and still in others a rod, with flattened side, is placed to prevent a too rapid flow of the oil. If they are properly handled and attended to and proper judgment is used in adjusting them, in accordance with the characteristics of the oil used, most of them will answer their purpose satisfactorily.

In those cups which feed with a wick, it is important that the number of strands in the wick should be in proper proportion to the limpidity or viscosity of the oil used, and in those cups separated with a metallic stem with a flattened side, the latter should be filed still flatter

or the stem removed entirely when a change is made from a limpid and easy-flowing oil to one which has a heavy body of uniform consistency.

In all cups exposed to varying temperatures, only such oils should be used as will not congeal and thereby become unable to flow and feed through the aperture. Frequently when changing from one oil to another, and especially when the oil first used was of a gummy character, and the new oil does not possess this objectionable quality, the oil may at first feed well enough through the aperture, without the necessity of changing its adjustment, but on account of its gradual loosening the almost imperceptible coating or gummy film on the sides of the cup, the latter is apt to obstruct the opening and the oil will be unable to force its passage through, and the bearing running warm, the oil will unjustly be condemned as being a poor lubricant.

Cups especially designed for feeding grease are also of varied construction and character. These cups should also have apertures proportionate to the melting quality of the grease used.

There are cups where it is intended to force the grease down by pressure or by springs, which consequently require much attention and adjusting and cannot be considered automatic feeders.

Those cups provided with metallic stems, resting on the shaft, to work on the principle that

the frictional heat conveyed through these stems will melt the grease and make it limpid enough to flow down on them, also fail to secure perfect lubrication, as they can only begin and continue to lubricate after sufficient heat has accumulated by which to keep the grease melting.

As running machinery under increased heat means expansion of the metal, abrasion of the parts and waste of power, the deficiency of grease lubrication is apparent. The only reliable lubricating with grease is through long-slotted apertures in the box, which allow the grease to lay directly on the parts in motion.

When lard oil and tallow oil were the only means for lubricating locomotive engines, these oils would readily solidify in their feeding cups in cold weather, and all the cups had to be equipped with steam mantles to keep the oil in a fluid condition. When the petroleum oils came into use they were applied with oil pumps and through sight-feed lubricators and the use of the latter became almost universal.

Some promoters of grease lubrication conceived the idea to apply grease to cylinder lubrication, and constructed special sight-feed cups intended to allow the grease kept liquid by steam to be carried drop by drop with the steam into the cylinder.

Disregarding all theory as to the process of

lubrication, they had grease compounds made of petroleum steam-refined cylinder stock and tallow oil. Lubricating cylinders with tallow having long ago been abandoned on account of the injurious action on the metal of the cylinders, the tallow combined now to form in conjunction with the impurities contained in steam-refined stock and the metallic abrasions, gummy deposits that accumulated in the cylinders and impeded the power. The application of grease for lubricating cylinders in this manner was also found inconvenient when the engine was stopped, and when the lubricant was exposed in winter to severe cold the grease became congealed and failed to flow until again liquified by the steam.

XVI.

SPECIFIC GRAVITY.

WEIGHT is the measure of gravity. The specific gravity of any body is the proportion which the weight of a certain amount of that body bears to the same amount of another body which is taken as standard. The standard adopted for solid and liquid bodies is water, at the temperature of 60° F.

The specific gravity of liquids is most accurately ascertained by means of the specific gravity bottle, which is so constructed as to hold exactly 1000 grains of distilled water. The water being emptied out and the bottle filled with the liquid to be tested, is weighed on a correct scale. The result gives the weight of a volume of the fluid equal in bulk to 1000 grains of water, and this weight, divided by 1000, represents the specific gravity of the liquid.

The specific gravity of oils and fats, which are all lighter than water, except some of the tar oils, is handily ascertained by means of the Baumé Hydrometer, constructed for the weighing

of liquids lighter than water. The oil is put in the hydrometer jar—a tall glass vessel—and the hydrometer placed in it so that it will float upright. The specific gravity of the oil is exactly indicated by the degree on the scale of the hydrometer to which the latter sinks. The measure is always taken at 60° F., and for every ten degrees above that temperature, one degree is subtracted from the reading, and for every ten degrees below 60° F., one degree is added to the reading on the hydrometer scale. Fats and oils, solid at ordinary temperature, should be heated until liquid enough to allow the hydrometer to float easily in them, to indicate their specific gravity.

Table of Baumé degrees, the specific gravity they represent and the corresponding weight of the liquids per gallon:

Degree Baumé.	Specific Gravity.	Pounds in One Gallon.
10	1.000	8.33
11	.9929	8.27
12	.9859	8.21
13	.9790	8.16
14	.9722	8.10
15 (castor oil)	.9655	8.04
16	.9589	7.99
17	.9523	7.93

18	.9459	7.88
19	.9395	7.83
20	.9333	7.78
21	.9271	7.72
22	.9210	7.67
23	.9150	7.62
24	.9090	7.57
25	.9032	7.53
26	.8974	7.48
27	.8917	7.43
28	.8860	7.38
29	.8805	7.34
30	.8750	7.29
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36	.8433	7.03
37	.8383	6.98
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40	.8235	6.86
41	.8187	6.82
42	.8139	6.78
43	.8092	6.74
44	.8045	6.70
45	.8000	6.66
46	.7954	6.63

47	.7909	6.59
48	.7865	6.55
49	.7821	6.52
50	.7777	6.48
51	.7734	6.44
52	.7692	6.41
53	.7650	6.37
54	.7608	6.34
55	.7567	6.30
56	.7526	6.27
57	.7486	6.24
58	.7446	6.20
59	.7407	6.17
60	.7368	6.14
61	.7329	6.11
62	.7290	6.07
63	.7253	6.04
64	.7216	6.01
65	.7179	5.98
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XVII.

REVIEW OF THE PETROLEUM OIL INDUSTRY TO 1915.

LOOKING over the history of the petroleum industry during the last decade there appears little to be recorded as new. The text books on the subject consist of products of compilations of facts long known and a chaos of suggestions for new procedures of little commercial value.

The latest and most elaborate work published in the German language, in 1913, by Engler, under the title "Das Erdoel" contains numberless reports on laboratory investigations and experiments, comments, and some of the many patents taken out here and abroad, but nothing strictly new that has not been forestalled some years ago by the elaborate researches and compilations by Sir Boverton Redwood published in England, the best information on the subject so far.

For many years it was supposed that petroleum oil could only be looked for in certain localities where it was easily obtained from deposits near the surface of the soil. Now with the greater

facilities for drilling to great depths, petroleum and gas have been found in many other localities, often at from two to three hundred feet underground, and it appears that oil and gas are stored almost anywhere at still greater depths.

Wherever in the bowels of the earth in prehistoric times vegetation and animal life existed and have for times inmemorable been left to decay and transformation underneath overlying strata, the mysterious work of nature appears to have changed them into deposits of gas and oil. Petroleum oil represents an endless series of compounds of hydrogen and carbon, the hydrogen predominating in the composition of the compounds of lighter specific gravity, and carbon in the heavier ones.

When petroleum is subjected to heat for its distillation, we separate its component parts from each other, those of lighter specific gravity being only followed by those of heavier specific gravity. Each different product of distillation when again subjected to distillation by itself, yields again compounds of lighter specific gravities and compounds of heavier ones. The distillation is carried on in various styles of apparatus, and different ways of operation, more or less known, or kept secret by corporations and individual refiners and manufacturers. There has been very little systematic study of the petroleum industry. Its

exploitation has been a wanton struggle only for the wealth to be obtained from it.

For commercial purposes we obtain by the distillation of petroleum oils: Benzine, gasoline, naptha, burning oils, lubricating oils, paraffine wax, and coke. Of all these products the burning oils became first of commercial value, and the demand for them superseding the use of tallow and wax candles for illumination, the efforts for greater improvements in the distilling process for their production were thereby much stimulated.

The energetic motive power of petroleum oils and gasoline having been discovered and applied to gas engines and automobiles, much of the steam power used for industrial purposes has been displaced by it, and the demand for gasoline has so enormously increased that the greatest efforts are at present being made for its increased production from petroleum oils. Numerous suggestions have been made, but with slight success so far, as it appears that from crude petroleum of a given degree of specific gravity only so much output of light hydrocarbon compounds can be obtained as the oil naturally possesses and no more; and it seems to be a fact that more output from heavier distillates can only be produced if an equivalent amount of hydrogen from outside sources can be fundamentally incorporated with

the heavier grades of the distillation. An increased supply of gasoline is now obtained by the process of compression of natural gas into the liquid state, natural gas also finding much useful application for heating and cooking purposes.

Burning oils are also employed for the production of motive power for internal combustion engines, but they do not possess as high explosive characteristics as the lighter hydrocarbon products (gasoline, naptha), and many attempts have been made for improvement by admixtures of peroxide of hydrogen, nitro-benzol and other chemicals.

As to the formation of new crude oil compounds by destructive distillation of distillates of petroleum oils under great heat and pressure, and obtaining therefrom an increased supply of gasoline, it appears to be a modification of the cracking process only. The so-called cracking process during distillation of petroleum oils as a means to increase the production of gasoline owes its origin to the fact that by the prevailing methods of too hurried distillation, irregular application of heat from coal fire and the too limited conducting power of the arising vapors to the condensing coils, a certain amount of back pressure on the vapors is produced which causes a portion of the developed vapors to be forced back into the bulk of the boiling oil. When distillation is

then interrupted and the heat reduced, the vapors that have been forced back by the back pressure and held in suspension in the oil are again raised at their proper temperature and condensed, to be added to the out-put of gasoline first obtained, the whole amount being in exact proportion to the amount of light hydrocarbon of the specific gravity of gasoline naturally contained in the oil.

The full amount of gasoline procurable from a given amount of petroleum oil is obtainable by distillation with slow and steady increase of the temperature produced by gas or fuel oil firing, and in a vessel with wide open surface connected with an overlaying large condenser with opening of equal size of said vessel, and so constructed inside as to permit of the rapid and free access of the arising vapors to condense on its water-cooled sides and prevent the falling back of any portion of them into the boiling oil.

Destructive distillation in connection with the nascent formation of hydrogen in the same apparatus connected with the condenser as above described, has been suggested, but has thus far not been successfully carried out on a commercial scale.

Little improvement in the production of lubricating oils that has not long been known, has been recorded, the manufacture of these oils has much increased and a great deal of attention is

given to so control the distillation as to retain paraffin wax in an amorphous state as viscosity in the oil.

Distillation with the admission of steam into the still naturally increases the yield of lubricating oil as thereby the hydrocarbons are not broken down by decomposition from contact with the hot iron of the still.

The only record of progress in the line of lubricating oils is the introduction of the so-called "Valve Oleum Oils" invented and patented by the author. By the process of their manufacture the fatty acids of the fatty oils are fixed to a metallic base, being thereby deprived of their injurious action on the metal of which machinery is constructed. Readily dissolving in petroleum oils, they impart to them the viscosity necessary for thorough lubrication, and join their valuable lubricating power with the excellent diffusing power of the petroleum lubricating oils.

Much improvement has been made in the production of paraffine wax whose application in the industrial world has much increased, and new improved machinery displacing the older methods in use has been advantageously introduced. Impecunious inventors are getting no encouragement to secure their rights by United States patents. They waste their time and energy and their limited means on their invention and to

secure it by a patent, to be left to the costly course of detecting infringers and prosecuting them through lengthy court proceedings, while wealthy unscrupulous corporations and piratically inclined individuals can through subsidized information and at the cost of a few cents per copy obtain from the patent office a full description of the invention.

It has been justly said that the great corporations and the individuals who made their enormous wealth of the petroleum industry never developed a new process or gave the trade a new idea, as is done by individual progressive men.

The claim to be able to change the characteristics of the petroleum oils so as to produce from them aniline oils seems to be chimerical. With judicious use of the forces of nature we can change water into ice, we can harness the power of electricity, can control fire and water to our service, we can secure iron from its ore; but we cannot make iron or change it into copper, or zinc into gold. We are only men, the most presumptuous animals in the universe; but we cannot be creators.

INDEX.

ACID in oil, 111, 112
Acidity in mineral oil, test for, 89
Adhesion oil, fluid, for belts, 82, 83
Adulteration of fatty oils, 84, 85
Alkali in mineral oil, test for, 89
tests, 86
Almond oil, 29, 30
Alumina, oleate of, preparation of, 72–75
Aluminium chloride, use of, for desulphurizing Ohio petroleum, 53, 54
-lanolate lubricant, 79
Aniline oil, 51
oils, from petroleum oils, 130
Automobile oils, 68
Axle grease, 100
dark, 104
in the cold way, 106, 107
yellow, 106
Axles, light, cohesion oil for, 68
rapidly running, heavily loaded, cohesion oil for, 68

BAUMÉ degrees, the specific gravity they represent and the corresponding weight of the liquids per gallon, table of, 121–123
hydrometer, 121, 122
Belt grease, 82
oil, 81, 82
Belts, fluid adhesion oil for, 82, 83
Benzine, crude, redistillation of, 55
deodorizing and bleaching, 62
Benzol, 51
Black lubricating oil, 59
Bleaching powder, bleaching oils with, 43
train oil, 45, 46
Blotter test, 95, 96
Bone grease, 19
Bones, lubrication of the joints of, 4, 5

CASTOR oil, 24, 25
adulteration of, 85
mineral, 75, 76
white valve-oleum, 77
Castoroleum, valve oleum, 77
Caustic soda, proportions of, to grease and oils for oleate of soda, 73
Chloride of lime, bleaching oils with, 43
Clarifying, refining and bleaching oils and fats, 41–47
Cleaning train oil, 45, 46
Coal-tar oil, 51
uses of, 51
Cocoanut oil, 29
Coefficient of friction, 2
Cohesion oils, 67, 68
Coke, utilization of, 61
Cold test, 94
Color test, 87, 88

Colza oil, 28
Compressors, lubricants for, 69
Copper, action of fats and oils on, 47
Copra, 29
Corn oil, 30, 31
Cosmoline, 59
Cotton mills, lubricant for spindles in, 60
seed oil, 27, 28
action of, on metal, 46
adulteration of, 90, 91
blown, 70
in lard oil, test for, 88
refining of, 42
Cracking process, 127, 128
Creosote, 50, 51
Cup grease, 100, 104
Cups and lubricators, 113–119
feeding with a wick, 116, 117
for grease, 117, 118
Cutting compound, 38
Cylinder oil from crude oil, 58, 59
steam refined, 58
valve oleum, 76, 77
oils, compounding of, 64, 65
pumps for applying, 113, 114
stock, filtered, 59
wear of, 108
Cylinders, injurious action of tallow in, 109
sources of injury to, 110, 111

DEBLOOMING petroleum oils, 61, 62
Degras, 23, 24
bleaching of, 44, 45
factitious, 24
use of, in compounding cylinder oils, 64, 65
Deodorizing oil, 43, 44
petrol oil, 62
train oil, 45, 46
Desulphurizing Ohio crude oils, 53, 54
Dieterich's Kafir-oil liniment, 61
Distillates, 55–57
Distillation of petroleum, 54–59
Drying oils, 13, 14

ELAIN, 19, 20
Engine oil, valve-oleum, 76
Essential oils, 12
Export oil, 56

FATS, action of metals on, 46, 47
and oils, 12–15
of animal and vegetable origin, 16–40
clarifying, refining and bleaching of, 41–47
composition of, 71
decomposition of, 109
Fatty acids, free, treatment of oils containing, 43
oil, compounding petroleum with, 65
oils, 13
adulteration of, 84, 85, 90–92
composition of, 71
decomposition of, 109
determination of mineral oils in, 87
in mineral oil, test for, 88
Filtered cylinder stock, 59
Fire test, 94, 95
Fish oils and spermaceti, 20–23
Fixed oils, 12, 13
Fluid adhesion oil for belts, 82, 83

Free fatty acids, treatment of oils containing, 43
Friction, 1–3
coefficient of, 2
laws of, 1–3
motion of, 2
quiescence, 2
rolling, 1, 2
sliding, 1
value of, 3
Frictional heat, 3
absorption of, by metal, 6
accumulation and disposal of, 7
creation of, 6, 7
Fuel oil, 50

GASOLINE engines, lubricant for, 60
from natural gas, 127
full amount of, obtainable by distillation, 128
increase in the production of, 126–128
Germany, receipts for lubricants used in, 67–70
Gingelly oil, 27
Glycerin, 39, 40
Golden machine oil, 58
Gravity, specific, 120–123
Grease lubricants, formulas for, 103–107
inert matter in, 101, 102
manufacture of, 102–107
Greases, 100–107
Green German soap, 34
Green oil, 49

HARNESS oil, 81
Headlight oil, 56
Heat, experiments on, by Rumford, 6, 7
frictional, 3
Hempseed oil, 28
Honey-drop engine oils, 71, 72, 75, 76
Horse tallow oil, 18, 19

ICE machines, lubricants for, 69
Illuminating oils, grades of, 49, 50
Iron, action of fats and oils on, 47

JOINT water, 5

KAFER ointment, carbolated, 61
Kerosene oil, deodorizing and bleaching, 62

LARD, 16, 17
oil, 17
adulteration of, 84, 90
test for cottonseed oil in, 88
for neutral oil in, 88
Laws of friction, 1–3
Lead, action of fats and oils on, 47
Leather oils, 80–83
preserving and water-proofing oils for, 81
Lighthouse oil, 50
Lime paste for rosin grease, 102, 103
Linolein, 33
Linoleum, valve-oleum, 77, 78
Linseed oil, 32, 33
adulteration of, 84
grease, 104–106
soap, soft, transparent, 35, 36
with a yield of 450 per cent., 37, 38
Lubricant, aluminium lanolate, 79

Lubricant, mineral, action of, on metal, 46
Lubricants for ice machine, 69
compressors, 69
threshing machines, 68
mineral oil, 68, 69
used in Germany, receipts for, 67–70
Lubricating as a chemical process, 5
grease, 100
oil, black, 59
oils, improvement in the production of, 128, 129
manufacture of, 63–70
practical tests of, 96, 97
simple way of testing, 95, 96
with rosin oils, 69, 70
petroleum oils for, 59–61
Lubrication, 3–11
inert matter for, 7, 8
Lubricators and cups, 113–119

MACHINERY, lubrication of, 5, 6
ordinary, lubricant for, 60
Manufacture of lubricating oils, 63–70
Marine sperm oil, 50
Marrow tallow, 19
Metal, absorption of frictional heat by, 6
Metals, action of fats and oils on, 46, 47
Mineral castor oils, 61, 75, 76
gelatines, 61
oil, detection of oleate of alumina in, 98, 99
determination of fatty oils in, 87
in fatty oils, test for, 88
lubricants, 68, 69
Mineral oil, test for acidity in, 89
alkali in, 89
soap in, 88, 89
oils, 14, 15, 48–50
Molasses for lubricating, 11
Moses pump, 114
Motion of friction, 2
Mustard seed oil, 32
Mutton fat, 18
Myrbane oil, 51

NATURAL gas, gasoline from, 127
Neat's foot oil, 18, 19
adulteration of, 90, 91
Neutral distillates, 56, 57
oil in lard oil, test for, 88
oils, purification and bleaching of, 57
Nigerseed oil, 32
Nitro-benzol, 51
-glycerin, 40

OHIO crude oils, 53, 54
Oil, acid in, 111, 112
mixtures, methods of testing, 89–99
Oils, action of metals on, 46, 47
and fats, 12–15
of animal and vegetable origin, 16–40
characteristics of, 12
clarifying, refining and bleaching of, 41–47
classes of, 12, 13
cohesion, 67, 68
cold test for, 94
color test for, 87, 88
deodorizing of, 43, 44
fire test for, 94, 95
illuminating, grades of, 49, 50
mineral, 48–50

Oils, simple and practical methods of testing, 89–99
test for viscosity of, 93, 94
testing of, 86–99
thickened, 70
Oleate of alumina in mineral oil, detection of, 98, 99
preparation of, 72–75
soda, 73, 74
proportions of caustic soda to grease or oils for, 73
Olive oil, 25, 26
action of, on metal, 46
adulteration of, 84

PAINT oil, cheap, 83
factitious, 83
Palm butter, 29
oil, 29
grease, 106
Paraffine oil, 49
treatment of, 57, 58
wax, 58
improvement in the production of, 129
uses of, 61
Peanut oil, 31, 32
Pennsylvania petroleum oils, 52, 53
Petrol oil, deodorizing of, 62
Petrolatum, 59
Petroleum, compounding of, with fatty oils, 65
distillation of, 54–59, 125, 126
occurrence of, 52
oil, origin of, 125
industry, review of, to 1915, 124–130
oils, 14, 15, 52–62
adulteration of fatty oils with, 90–92
deblooming of, 61, 62
for lubricating, 59–61
Petroleum oils, formation of new crude oil compounds from, 127, 128
motive power of, 126
production of aniline oils from, 130
to give a viscous consistency to, 64
proceeds of distillation of, 55, 56, 126
uses of, 60, 61
Picric acid, 50
Pine tar, 39
Plumbago, use of, for lubrication, 7, 8
Poppyseed oil, 30
Practical suggestions, 108–112
Prime white oil, 56
Pumps for applying cylinder oils, 113, 114

QUIESCENCE of friction, 2

RAILWAY, traction on, 3
Rapeseed oil, 28
action of, on metal, 46
blown, 70
Receipts for lubricants used in Germany, 67–70
Red oil, 19, 20, 57
Residuum oils, uses of, 61
Review of the petroleum oil industry to 1915, 124–130
Rolling friction, 1, 2
Rosin, 38, 39
grease, 102, 103
lime paste for, 102, 103
oil, 38, 39
oils, lubricating oils with, 69, 70

Rosin oils, use of, in compounding lubricating oils, 66
Rumford, experiments by, 6, 7

SEAL oil, 22
Sesame oil, 27
Sewing machine oil, 69
Shale oil, 49
Sight-feed cup, 114, 115
Signal oil for lanterns, 60
Sliding friction, 1
Soap, green German, 34
in mineral oil, test for, 88, 89
soft linseed oil, with a yield of 450 per cent., 37, 38
receipts for, 34–38
transparent linseed oil, 35, 36
transparent soft, in the semi-warm way, 36, 37
Soda, oleate of, 73, 74
proportions of caustic soda to grease or oils for, 73
Soft linseed oil soap with a yield of 450 per cent., 37, 38
soap, receipts for, 34–38
transparent, in the semi-warm way, 36, 37
linseed oil, 35, 36
Solid lubricants, 100–107
Specific gravity, 120–123
Sperm oil, 21, 22
adulteration of, 84, 85
Spermaceti, 20, 21
and fish oils, 20–23
Spindle oil, 57
Spindles in cotton mills, lubricant for, 60
Standard white oil, 56
Steam-refined cylinder oil, 58
Straight run distillate, 56
Suggestions, practical, 108–112
Sunflower oil, 26, 27

TABLE of Baumé degrees, the specific gravity they represent and the corresponding weight of the liquids per gallon, 121–123
of proportions of caustic soda to grease or oils for oleate of soda in the manufacture of valve-oleum lubricating oils, 73
Tallow, 17, 18
cleaning and bleaching of, 45
injurious action of, in cylinders, 109
oil, 18
action of, on metal, 46
Tanners, oil for use by, 81
Tar oils, 50, 51
Test, cold, 94
fire, 94, 95
Testing lubricating oils, 95–97
oils, 86–99
Tests, practical, of lubricating oils, 96, 97
Thickened oils, 70
Threshing machines, lubricants for, 68
Tin, action of fats and oils on, 47
Traction, 3
Train and whale oils, 22, 23
oil, cleaning, bleaching and deodorizing of, 45, 46
Transparent linseed oil soft soap, 35, 36
soft soap in the semi-cold way, 36, 37
Turpentine, 38, 39

VALVE-OLEUM castor oil, white, 77
castoroleum, 77

Valve-oleum cylinder oil, 76, 77
engine oil, 76
gelatine, 71, 72
leather preserving and water-proofing oils, 81
linoleum, 77, 78
oils, 71–78
origin of, 78, 79
Zola axle grease, 103
Vaseline, 59
Vegetable oils, 13
Viscosity, 93, 94
Volatile oils, 12, 14

WATER-WHITE oil, 56
West Virginia oil, 59
Whale and train oils, 22, 23
oil, action of, on metal, 46
Wood, distillation of, 50, 51
tar oil, 50
Wool fat, 23, 24
use of, in compounding cylinder oils, 64, 65

ZINC, action of fats and oils on, 47

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